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ABSTRACT

This guide is a competency-based vocational curriculum designed to provide educators with viable ethanol (100 percent alcohol) engine conversion procedures stated in simple terms and set in a flexible educational environment. The curriculum is designed so that educators can form various combinations of instructional activities and resource materials without jeopardizing the intent of the guide. The curriculum guide's 17 units are designed according to competency-based standards. Each learning unit (task) contains a terminal performance objective, micro-performance objectives, learning steps, resources, learning activities, and information sheets. A bibliography is included. (KC)

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A COMPETENCY BASED CURRICULUM GUIDE: ETHANOL SPARK IGNITION ENGINE CONVERSION

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CE 029 476

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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TO THE INSTRUCTOR

A Competency Based Curriculum Guide: Ethanol Spark Ignition Engine Conversion makes it possible for agriculture and automechanics instructors to play an instrumental role in solving the problems of motor fuel cost and availability. Currently, various strengths and types of alcohol are being developed and tested as alternative motor fuels. At the same time, alcohol engine conversion technology is being refined to make alcohol fuel distillation a worthwhile endeavor. The initial results of both undertakings are quite promising. Vocational education in the largely rural state of Illinois is destined to be an important part of both alcohol fuel production and engine conversion, not only in terms of research and development but also in terms of training and job placement. The competency based vocational curriculum set forth in this guide provides educators with viable ethanol (100% alcohol) engine conversion procedures stated in simple terms and set in a flexible educational environment. The curriculum is so designed that educators can form various combinations of instructional activities and resource materials without jeopardizing the intent of the guide.

The research for this project developed in several phases. The technology responsible for refining ethanol engine conversion techniques was spearheaded by the U.S. Department of Energy's specialist on alcohol-fueled engines, Dr. Richard F. Blaser. These techniques were later honed, applied, and recorded by agriculture mechanics instructor Bob Howard and automechanics instructor George Cox. To validate the engine conversion competencies/techniques, project members sent twenty-five questionnaires to vocational educators, mechanics, and experimenters who were known to be involved in alcohol engine conversion. The results of the questionnaire have been processed, and the competencies have been ranked. Appreciation is extended to those who participated in the project by answering the questionnaire. The curriculum guide itself was designed according to competency based standards and ingredients. Dr. Urban T. Oen, specialist in competency based vocational planning, deserves a goodly amount of credit for his services as curriculum consultant for this project.

Recognition is given to the following individuals for their valuable contributions to the alcohol fuels curriculum at Southeastern Illinois College: Dr. Harry W. [illegible]oell, President; Robert Gregg, Dean of Technology; Dr. Mary Jo Oldham, Chairperson of Home Economics; Sam Porter, Chairperson of Science Division; Dick Hagan, Director of Continuing Education; Paul Talaski, Visual Aids Specialist; Bob Howard, Project Director; George Cox, Associate Director; and Melva Casey, Secretary.

Brittain A. Blair

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Curriculum Writer

Illinois State Board of Education

Department of Adult, Vocational and Technical Education
Research and Development Section

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___ Career Education
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___ Administrator (Pre-Service)
___ 7-8
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___ 9-10
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16. General Description (State the general objective and suggested method of use. Summarize the content and tell how it is organized. Continue on back of this sheet or on another sheet, if necessary.):

The purpose of this curriculum guide is to provide agriculture and automechanics instructors with viable instructional and technological guidelines to ethanol spark ignition engine conversion. Southeastern Illinois College and the Illinois State Board of Education feel that the most effective approach of presenting engine conversion information is through competency based instruction. Thus, the curriculum guide's seventeen learning units designed according to competency based standards serve to convey the conversion techniques developed and refined at Southeastern.

17. Person Completing this Abstract: Brittain A. Blair, Curriculum Writer

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TASK LIST

TASK	TASK DESCRIPTION
100	Explain the basic theoretical principles governing the carburetion and compression systems of a spark ignition engine.
200	Compare gasoline and ethanol.
300	Explain the major experimentation of ethanol spark ignition engine conversion.
400	Identify the modifications that must be made to the carburetion system of an ethanol spark ignition engine.
401	Construct and install an ethanol fuel preheater for a spark ignition engine.
402	Install a 190°F thermostat in the upper radiator hose of a spark ignition engine.
403	Test the manifold temperature controls on a spark ignition engine.
404	Enlarge the areas of the idle circuit tubes in a carburetor for a spark ignition engine.
405	Enlarge the areas of the holes in the main jets of a carburetor for a spark ignition engine.
406	Raise the level of fuel in the fuel bowl of a carburetor for a spark ignition engine.
500	Install high compression ratio pistons in a spark ignition engine.
600	Identify the modifications that must be made to the ignition system of an ethanol spark ignition engine.
601	Advance the initial timing of the distributor of a spark ignition engine.
602	Select, gap, and install higher heat range spark plugs in a spark ignition engine.
700	Install a high torque starter in a spark ignition engine.
800	Test and analyze a spark ignition engine converted to ethanol.
900	Identify the major techniques and developments of ethanol engine conversion as stated in current magazine and journal articles.

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A LEARNING GUIDE

100

TASK Explain the basic theoretical principles governing the carburetion and compression systems of a spark ignition engine.

PURPOSE Since the ethanol conversion technician modifies the carburetor and changes the compression ratio in the engine conversion process, the basic theoretical reasons for performing such changes must be fully understood. This knowledge enables the conversion technician not only to justify the conversion operation but also to troubleshoot the carburetion and compression systems of any spark ignition engine undergoing the ethanol conversion. As a result, the technician's increased efficiency in converting engines saves money and time.

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100 North First Street, Springfield, Illinois 62777

TERMINAL PERFORMANCE OBJECTIVE

Given a written criterion exam, explain the basic theoretical principles governing the carburetion and compression systems of a spark ignition engine. Mastery of this task will be shown by scoring 24 out of 30 or 80% on the exam.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Explain the concepts of atomization and vaporization.

2. Explain the concept of air to fuel ratio.

3. Explain the concept of compression ratio.

4. Explain the basic theoretical principles governing the carburetion and compression systems of a spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Explain the concepts of atomization and vaporization.

LEARNING STEPS	RESOURCES
1. Read Resource 1 for an explanation of the concepts of atomization and vaporization.	1. Textbook: Fundamentals of Service--Engines, John Deere, Chapter 3, pg. 8, in Learning Resources Center.
2. Listen to Resource 2A or read Resource 2B for an explanation of the concepts of atomization and vaporization.	2. A. Audio Presentation 100-001-001: "Concepts of Atomization and Vaporization" in Learning Resources Center. B. Information Sheet 100-001-002: "Concepts of Atomization and Vaporization (Script)" in this Learning Guide.
3. Complete Resource 3 to practice explaining the concepts of atomization and vaporization.	3. Activity Sheet 100-001-003: "Explain the Concepts of Atomization and Vaporization" in this Learning Guide.
4. Go to Resource 4 after Instructor approves Activity Sheet.	4. Micro-Performance Objective #2 in this Learning Guide.

INFORMATION SHEET

100-001-002

The Concepts of Atomization and Vaporization (Script)

Automobile carburetors do a poor job of vaporizing fuel. In fact, the most a carburetor will do is atomize the fuel. For a liquid fuel to burn completely in an engine, it must be changed to a vapor. Since most of the fuel leaving the carburetor and going into the manifold is in an atomized state (small liquid droplets), we depend on engine heat to help vaporize these droplets.

For adequate vaporization, make sure that the engine's manifold heat control valve is operating properly. Furthermore, if the engine is equipped with a heated air intake system, make sure it is working properly. Finally, check the water temperature to see if it is up to prescribed specifications. We are installing 190°F thermostats in our engine conversions and having good performance results. Remember, on alcohol-fueled engines--especially those using ethanol, or 100% alcohol, which vaporizes at 173°F—heat is the name of the game. This is why a cool running alcohol engine will provide very poor performance.

ACTIVITY SHEET

100-001-003

Explain the Concepts of Atomization and Vaporization

Using what you have learned from John Deere's Fundamentals of Service--Engines, the audio presentation, or the information sheet, explain in your own words the concepts of atomization and vaporization. Once you have finished, submit these written explanations to your instructor for approval.

MICRO-PERFORMANCE OBJECTIVE #2

Explain the concept of air to fuel ratio.

LEARNING STEPS	RESOURCES
1. Read Resource 1 for an explanation of the concept of air to fuel ratio.	1. Textbook: Fundamentals of Service--Engines, John Deere, Chapter 1, pp. 1-3, and Chapter 3, pp. 8-19, in Learning Resources Center.
OR	
2. Listen to Resource 2A or read Resource 2B for an explanation of the concept of air to fuel ratio.	2. A. Audio Presentation 100-002-001: "The Concept of Air to Fuel Ratio" in Learning Resources Center. B. Information Sheet 100-002-002: "Concept of Air to Fuel Ratio (Script)" in this Learning Guide.
3. Complete Resource 3 to practice explaining the concept of air to fuel ratio.	3. Activity Sheet 100-002-003: "Explain the Concept of Air to Fuel Ratio" in this Learning Guide.
4. Go to Resource 4 after Instructor approves Activity Sheet.	4. Micro-Performance Objective #3 in this Learning Guide.

INFORMATION SHEET

100-002-002

The Concept of Air to Fuel Ratio (Script)

When converting a gasoline-powered automobile engine to an ethanol-powered engine, we must modify the carburetor to allow more fuel to flow through the idle and high speed circuits. We accomplish this by drilling the high speed jets and the idle tubes larger. On some carburetors, it may also be necessary to alter the acceleration circuit in order to discharge a larger amount of fuel. Experience has shown that Holley acceleration circuits usually need to be enlarged, while Rochester acceleration circuits need no change.

When drilling the jets larger, we must drill as straight and true as possible. In selecting the proper drill bit, remember that the Area of the hole must be enlarged by 40%. For instance, on a Rochester carburetor we were converting recently, the high speed jets were .048" in diameter. By using the formulas $A = \pi \cdot r^2$, $(40\%\text{ of Area} + \text{Area}) \div 3.14 = x$, and $\sqrt{x} \cdot 2$, we found that we needed to enlarge the jet holes to .057" in diameter. When looking for a .057" bit, we found that a #54 drill bit measured the closest to .057". We drilled the jets with this drill bit and discovered that it worked fine.

ACTIVITY SHEET

100-002-003

Explain the Concept of Air to Fuel Ratio

Using what you have learned from John Deere's Fundamentals of Service--Engines, the audio presentation, or the information sheet, explain in your own words the concept of air to fuel ratio. Once you have finished, submit this written explanation to your instructor for approval.

MICRO-PERFORMANCE OBJECTIVE #3

Explain the concept of compression ratio.

LEARNING STEPS	RESOURCES
1. Read Resources 1A and 1B for an explanation of the concept of compression ratio.	1. A. Textbook: Fundamentals of Service--Engines, John Deere, Chapter 1, pp. 3-7, 26-27, in Learning Resources Center.
OR	B. Textbook: Fundamentals of Service--Fuels, Lubricants and Coolants, John Deere, pp. 1-4, in Learning Resources Center.
2. Listen to Resource 2A or read Resource 2B for an explanation of the concept of compression ratio.	2. A. Audio Presentation 100-003-001: "The Concept of Compression Ratio" in Learning Resources Center.
	B. Information Sheet 100-003-002: "Concept of Compression Ratio (Script)" in this Learning Guide.
3. Complete Resource 3 to practice explaining the concept of compression ratio.	3. Activity Sheet 100-003-003: "Explain the Concept of Compression Ratio" in this Learning Guide.
4. Go to Resource 4 after Instructor approves Activity Sheet.	4. Micro-Performance Objective #4 in this Learning Guide.

100-003-002

The Concept of Compression Ratio (Script)

So that the fuel in an internal-combustion engine burns efficiently, we must compress the fuel-air mixture acting upon that engine. An engine's compression ratio tells us how much the fuel-air mixture is compressed in terms of volume. One can compute compression ratio by finding the volume of fuel-air mixture that a cylinder will hold when the piston is at the farthest point of its downward travel, or bottom dead center (b.d.c.), relative to the volume of fuel-air mixture when the piston is at the farthest point of its upward travel, or top dead center (t.d.c.).

Usually, the higher the compression ratio the more efficient the fuel will burn. However, any fuel will have its limits of compression. Gasoline, for instance, can go no higher than an 8:1 compression ratio and still burn efficiently. Compression ratio limitations occur when a certain compression point is reached causing fuels to burn unevenly. At this point, they tend to explode (spark knock and precombustion) resulting in poor combustion.

One of alcohol's major advantages as a fuel is its relatively high compression ratio limit. Alcohol, being a more stable fuel than most, will burn evenly at a high compression ratio: a ratio as high as 15:1 is not uncommon for maximum efficiency. However, the most reliable efficiency seems to occur at a 12.5:1 compression ratio.

Anytime compression ratio is raised by one, the amount of push at the top of the piston is increased four times. For example, by increasing an engine's compression ratio from 8:1 to 10:1, we increase the amount of push available to the piston by eight. Thus, it is easy to see that a gasoline engine with a compression ratio of 8:1 is not going to have as much power as an alcohol engine has at a compression ratio of 12.5:1.

ACTIVITY SHEET

100-003-003

Explain the Concept of Compression Ratio

Using what you have learned from Fundamentals of Service--Engines, Fundamentals of Service--Fuels, the audio presentation, or the information sheet, explain in your own words the concept of compression ratio. Once you have finished, submit this written explanation to your instructor for approval.

MICRO-PERFORMANCE OBJECTIVE #4

Explain the basic theoretical principles governing the carburetion and compression systems of a spark ignition engine.

LEARNING STEPS	RESOURCES
1. Review Resource 1 for an explanation of the basic theoretical principles governing the carburetion and compression systems of a spark ignition engine.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. Complete Resource 2 when you are ready to be evaluated on this objective.	2. Written Criterion Exam Task 100 from Instructor.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

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A LEARNING GUIDE

200

TASK Compare gasoline and ethanol.

PURPOSE In converting a gasoline burning engine to an ethanol burning engine, it is important for the ethanol conversion technician to know what happens to the engine when gasoline and ethanol are used and why it happens. Once gasoline and ethanol are compared in these terms, modifications to make the engine run smoothly on ethanol are justified, and valuable troubleshooting knowledge is acquired. Knowing the differences and similarities of these two fuels makes the conversion technician more of an asset to an employer.

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TERMINAL PERFORMANCE OBJECTIVE

Given a written criterion exam, compare gasoline and ethanol. Mastery of this task will be shown by scoring 24 out of 30 or 80% on the exam.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Compare the chemical properties of gasoline and ethanol.
2. Compare the functional characteristics of gasoline and ethanol.
3. Identify the advantages and disadvantages of using gasoline and ethanol.
4. Compare gasoline and ethanol.

MICRO-PERFORMANCE OBJECTIVE #1

Compare the chemical properties of gasoline and ethanol.

LEARNING STEPS	RESOURCES
1. Read Resource 1A or 1B to compare the chemical properties of gasoline and ethanol.	1. A. Textbook: Organic Chemistry, Morrison and Boyd, pp. 492-552, in Learning Resources Center. B. Book: Internal Combustion Engines and Air Pollution, Obert, pp. 1-24, in Learning Resources Center.
2. View Resource 2 to observe the chemical properties of gasoline and ethanol being compared.	2. Instructor Demonstration performed in Lab.
3. Complete Resource 3 to practice comparing the chemical properties of gasoline and ethanol.	3. Activity Sheet 2[illegible]-001-001: "Compare the Chemical Properties of Gasoline and Ethanol" in this Learning Guide.
4. Go to Resource 4 after Instructor approves Activity Sheet.	4. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

200-001-001

Compare the Chemical Properties of Gasoline and Ethanol

Using what you have learned from the reading assignments and instructor demonstration, follow the instructions below. Once you have finished, submit your written answers to the instructor for approval. If needed, use a separate piece of paper on which to write your answers.

1. Describe the chemical structures and properties of gasoline and ethanol:

2. Identify the three different systems of alcohols:

3. Describe the physical and thermal properties of gasoline and ethanol:

4. Describe the various forms and sources of gasoline and ethanol:

5. Explain Alcoholometry:

MICRO-PERFORMANCE OBJECTIVE #2

Compare the functional characteristics of gasoline and ethanol.

LEARNING STEPS	RESOURCES
1. Read Resource 1A and 1B, or 1C and 1D to compare the functional characteristics of gasoline and ethanol.	1. A. Report: "Seminar on Automobile Fuel Efficiency," Meader, Report No. M.78-96, in Learning Resources Center. B. Report: "Prepared Statement of Dr. Serge Gratch," representative of Ford Motor Company, Special Hearing on Alcohol Fuels conducted by U.S. Senate Committee on Appropriations, January 31, 1978, in Learning Resources Center. C. Report: "Automobile Fuels--Outlook for the Future," Bidwell, pp. 625-681, in Learning Resources Center. D. Textbook: Fundamentals of Service--Fuels, Lubricants and Coolants, John Deere, pp. 4-9, in Learning Resources Center.
2. View Resource 2 to observe the functional characteristics of gasoline and ethanol being compared.	2. Instructor Demonstration performed in Lab.
3. Complete Resource 3 to practice comparing the functional characteristics of gasoline and ethanol.	3. Activity Sheet 200-002-001: "Compare the Functional Characteristics of Gasoline and Ethanol" in this Learning Guide.
4. Go to Resource 4 after Instructor approves Activity Sheet.	4. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

200-002-001

Compare the Functional Characteristics of

Gasoline and Ethanol

Using what you have learned from the reading assignments and instructor demonstration, list below the functional characteristics of gasoline and the functional characteristics of ethanol. Once you have finished, submit the lists to your instructor for approval.

Gasoline	Ethanol

MICRO-PERFORMANCE OBJECTIVE #3

Identify the advantages and disadvantages of using gasoline and ethanol.

LEARNING STEPS	RESOURCES
1. Read Resources 1A, 1B, 1C and 1D to identify the advantages and disadvantages of using gasoline and ethanol.	1. A. Report: "Alcohols--A Technical Assessment of Their Application as Fuels," American Petroleum Institute, pp. 27-53, in Learning Resources Center. B. Report: "Alcohol Fuels--1980 Expectations," U.S. Department of Energy, in Learning Resources Center. C. Report: "Engine Conversion for Alcohol Fuels," Special Hearing on Alcohol Fuels conducted by U.S. Senate Committee on Appropriations, January 31, 1978, in Learning Resources Center. D. Report: "Excerpt from General Motors Research Laboratories," Colucci, Special Hearing on Alcohol Fuels conducted by U.S. Senate Committee on Appropriations, January 31, 1978, in Learning Resources Center.
2. Read one of the following Resources to further identify advantages and disadvantages of using gasoline and ethanol: 2A, 2B, or 2C.	2. A. Compilation: Alcohol Motor Fuels for Internal Combustion Engines: A Compilation of Background Technical Information, Blaser, pp. ii-vii, in Learning Resources Center. B. Information Sheet 200-003-001: "The Congressional Alcohol Fuels Caucus Presents an Alcohol Fuels Engine Exhibit" in this Learning Guide.

(continued on next page)

MICRO-PERFORMANCE OBJECTIVE #3

Continued.

LEARNING STEPS	RESOURCES
	C. Report: "Fuel from Farms--A Guide to Small Scale Ethanol Production," Solar Energy Research Institute, Appendix C, pp. 1-3, in Learning Resources Center.
3. View Resource 3 to observe the advantages and disadvantages of using gasoline and ethanol.	3. Instructor Demonstration performed in Lab.
4. Complete Resource 4 to practice identifying the advantages and disadvantages of using gasoline and ethanol.	4. Activity Sheet 200-003-002: "Identify the Advantages and Disadvantages of Using Gasoline and Ethanol" in this Learning Guide.
5. Go to Resource 5 after Instructor approves Activity Sheet.	5. Micro-Performance Objective #4 in this Learning Guide.

INFORMATION SHEET

200-003-001

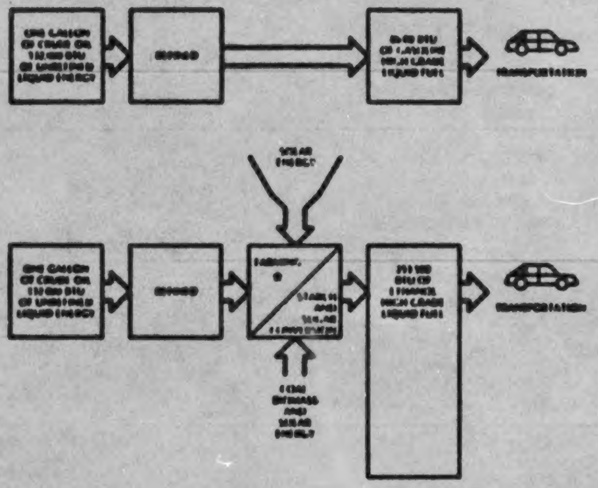
THE CONGRESSIONAL
ALCOHOL FUELS CAUCUS
PRESENTS AN

ALCOHOL FUELS — ENGINE EXHIBIT

ON THE GROUNDS OF THE
UNITED STATES CAPITOL
JUNE 18, 1980
IN COOPERATION WITH THE
DEPARTMENT OF ENERGY'S
OFFICE OF ALCOHOL FUELS
AND
OFFICE OF CONSUMER AFFAIRS

REMEMBER!

Each gallon of ethanol used for transportation saves us more than 1.5 gallons of imported crude, thus reducing our dependence on foreign countries for our energy supplies. (The savings are displayed on the chart below.)



* Fourteen pounds of seed corn planted in an acre of soil and treated with 3,702,000Btu of fertilizers (API study) will yield about 100 bushels (5,600 lbs.) of corn, which will convert into 250 gallons of ethanol or 18,900,000 Btu of high-grade liquid fuel. In addition, the co-products include 1,700 lbs of high quality distillers meal, 1,500 lbs. of CO_2, as well as 20,000,000 Btu of crop residue available for a variety of purposes, including fertilizers. The sun has paid a mighty dividend.

EXHIBIT	FUEL	EXHIBITOR	CONTRACTS
Beta modified 350 cubic inch General Motors engine in a Chevrolet pick-up truck	Can be switched from gasoline to alcohol (ethanol or methanol)	Students and Faculty Delta Vocational Technical School Marked Tree, Arkansas	Mr. Bill Stanley Delta Vocational Tech. College P.O. Box 279 Marked Tree, Arkansas
Beta modified 400 cubic inch diesel engine in a John Deere tractor	Blend of ethanol with vegetable oil, castor oil, or linseed oil	Southeastern Illinois College Harrisburg, Illinois Bob Howard and George Cox, Project Directors	
Modified 404 cubic inch diesel engine mounted for display	Blend of ethanol and vegetable oil		
Modified 350 cubic inch General Motors engine mounted for display	Multi-fuel		
Modified 505 cubic inch diesel engine in a Case tractor	Ethanol	Engine retrofit project of the Southern Ilinois College with the participation of the educational branch located in Vienna Correctional Center	Mr. Hartzel Black Vienna Correctional Center Vienna, Illinois 62995
Modified 3.5 horsepower engine in a go-cart	Ethanol, gasoline, or vegetable oil		
Beta modified 301 cubic inch 1979 Pontiac engine mounted for display	Multi-fuel		
Standard 350 cubic inch Chevrolet engine mounted for display	Ethanol		
Alcohol Fuel engine conversion kit for standard automobile engines	Switchable from gasoline to alcohol (ethanol and methanol)	Dr. Bill Harris and Dr. R.R. Davidson Texas A&M University	Dr. Bill Harris/Dr. R R. Davidson Chemical Engineering Dept. Texas A&M University College Station, TX 77840
Modified six cylinder Plymouth engine in a 1979 Plymouth Volare	Ethanol	Ashland Oil Company	Harold Messick Ashland Oil Company 222nd St. & Front St. Ashland, KY 41101
Standard four cylinder Ford Model A engine in a restored 1929 Ford Model A truck	Ethanol	Robinson Secondary School Fairfax, Virginia	George Price Robinson Secondary School 5035 Sideburn Road Faifax, VA. 22032
(2) modified six cylinder Chrysler engines in 1979 Chrysler unmarked police cars	Methanol	New York City Police Department	Eugene Masci New York Police Department 1 Police Plaza New York, NY 10038
Modified 250 cubic centimeter Yamaha motorcycle engine in a Yamaha motorcycle	Ethanol	National Park Service U.S. Park Police	Officer Mike Foster U.S. Park Police (202) 523-0056
Hybrid alcohol-electric powered lawn tractor	Ethanol/battery	National Park Service National Capitol Region Brentwood Maintenance Facility	John Hoke (202) 282-7192/426-3760 (For any questions on hybrid technology)
Sterling engine mounted for display	Multi-fuel		
Lawn mowers	Alcohol		James Wolfe (202) 426-6637

The Congressional Alcohol Fuels Caucus

June 18, 1980

In Cooperation with the

Department of Energy's

Office of Alcohol Fuels

and

Office of Consumer Affairs

Preface

At the beginning of the Century, gasoline and diesel oil were established as the leading transportation fuels because petroleum was readily available and relatively inexpensive. As a result, internal combustion engines have been designed to accommodate these non-renewable liquid fossil fuels. Little consideration has been given to the fact that other liquid fuels are available to drive the nation's transport.

Times have changed. World oil supplies have been recognized as finite and, as a result, the price of gasoline at the pump is rising. To offset this problem, there is a growing movement in our country to develop alternative liquid fuels from domestically available, renewable sources.

Fuel grade alcohol is the only synfuel now being produced in any substantial quantity. The alcohols primarily in use as fuel at this time are ethanol (grain alcohol) and methanol (wood alcohol). Both products are recognized as high-grade liquid fuels. Ethanol from biomass is commercially produced in numerous facilities throughout the country. Ethanol is blended with gasoline to produce Gasohol, which is now being sold in over 5,100 gasoline stations across the country. Methanol has been used to fuel racing cars for years. Ethanol production from cellulosic conversion and methanol production from coal are presently in the demonstration stage.

Gasohol can be burned readily in internal combustion engines. However, engines must be modified to burn 100% ethanol or methanol, because the chemical and physical properties of the alcohols differ from those of conventional hydrocarbon fuels, such as gasoline and diesel. Present day engines can be modified to accommodate the characteristics of alcohol fuels.

In order to optimize the result of using alcohol fuels on a nationwide basis, it is necessary to coordinate production of both the fuels and the engines. It is important for the auto industry and engine mechanics to work in harmony with the pioneers of the alcohol fuel industry to ensure that fuel and engine work compatibly. The technology is available to accomplish this first step toward our nation's energy independence.

ACTIVITY SHEET

200-003-002

Identify the Advantages and Disadvantages of Using Gasoline and Ethanol

Using what you have learned from the reading assignments and instructor demonstration, list below the advantages and disadvantages of using gasoline and ethanol. Once you have finished, submit the lists to your instructor for approval.

Gasoline	Ethanol
Advantages:	**Advantages:**
Disadvantages:	**Disadvantages:**

MICRO-PERFORMANCE OBJECTIVE #4

Compare gasoline and ethanol.

LEARNING STEPS	RESOURCES
1. Review Resource 1 to compare gasoline and ethanol.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. Listen to Resource 2A or read Resource 2B to compare gasoline and ethanol.	2. A. Audio Presentation 200-004-001: "Comparing Gasoline and Ethanol" in Learning Resources Center.
OR	B. Information Sheet 200-004-002: "Comparing Gasoline and Ethanol (Script)" in this Learning Guide.
3. View Resource 3 to compare gasoline and ethanol.	3. Slide/Tape Presentation 200-004-003: "Gasoline, Ethanol and Gasohol: Advantages and Disadvantages as Engine Fuels." For information on obtaining the filmstrip version of this presentation write to: Illinois Vocational Curriculum Center Sangamon State University Springfield, Illinois 62708
4. Complete Resource 4 when you are ready to be evaluated on this objective.	4. Written Criterion Exam Task 200 from Instructor.
5. See Resource 5 to begin next Learning Guide.	5. Instructor.

INFORMATION SHEET

200-004-002

Comparing Gasoline and Ethanol (Script)

Gasoline and alcohol have been in use as motor fuels since the early 1900's. Originally, gasoline was merely a by-product of crude oil, whereas alcohol played a substantial role in running farm machinery and equipment. However, in the 1930's, the trend seemed to change from alcohol-powered engines to gasoline-powered engines, thus giving gasoline the market we know today. The major reasons for the widespread use of gasoline were its availability and low price.

Now, with the oil shortage and the escalating prices at the gas pump the viability of gasoline is in question. People are looking for a more reliable and cheaper source of fuel. Alcohol is once again being considered as a solution to the world's gasoline woes. Comparisons show that gasoline has a higher B.T.U. content than alcohol. Gasoline has a B.T.U. content of approximately 125,000/gallon, while alcohol has a B.T.U. content of approximately 85,000/gallon. Looking at this, one might think that a gasoline-powered engine has more power. However, ethanol (100% alcohol) has an octane rating of 115, while gasoline has a rating of 84 or less. Because of the higher octane rating, ethanol can accommodate a higher compression ratio (more power) than gasoline. Compression ratios as high as 15:1 are not uncommon in engines using ethanol. If we try to burn gasoline at higher compression ratios, the engine has a tendency to spark knock and preignite (gasoline burns efficiently at approximately an 8:1 compression ratio).

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A LEARNING GUIDE

300

TASK Explain the major experimentation of ethanol spark ignition engine conversion.

PURPOSE Before attempting to convert a spark ignition engine to ethanol, the ethanol conversion technician reviews what other mechanics in the conversion area have accomplished. By knowing the successes and failures of others, the technician justifies the conversion operation and avoids costly and time-consuming mistakes.

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TERMINAL PERFORMANCE OBJECTIVE

Given a written criterion exam, explain the major experimentation of ethanol spark ignition engine conversion. Mastery of this task will be shown by scoring 16 out of 20 or 80% on the exam.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Explain the early experimentation of ethanol spark ignition engine conversion.

2. Explain the current experimentation of ethanol spark ignition engine conversion.

3. Explain the major experimentation of ethanol spark ignition engine conversion.

MICRO-PERFORMANCE OBJECTIVE #1

Explain the early experimentation of ethanol spark ignition engine conversion.

LEARNING STEPS	RESOURCES
1. Read Resources 1A and 1B, or 1C and 1D for an explanation of the early experimentation of ethanol engine conversion.	1. A. Magazine Article: "Alcohol Fuels—Can They Replace Gasoline?" Popular Science, pp. 25-34, in Learning Resources Center. B. Magazine Article: "Ford's Dream for Better World—Alcohol Fuel," Earth Energy, pg. 1 cont. on pg. 11, in Learning Resources Center. C. Magazine Article: "Alcohol as an Alternative Fuel," Kirik, pp. 622-624, in Learning Resources Center. D. Report: "Alcohol Fuels: Opportunities for Idaho," U.S. Department of Energy, pp. iv-v, in Learning Resources Center.
2. Complete Resource 2 to practice explaining the early experimentation of ethanol engine conversion.	2. Activity Sheet 300-001-001: "Explain the Early Experimentation of Ethanol Spark Ignition Engine Conversion" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

300-001-001

Explain the Early Experimentation of Ethanol Spark Ignition Engine Conversion

Using what you have learned from the reading assignments, explain in your own words the early experimentation of ethanol engine conversion by Henry Ford, foreign countries, and Indianapolis 500 race car drivers. Once you have finished, submit these written explanations to your instructor for approval.

MICRO-PERFORMANCE OBJECTIVE #2

Explain the current experimentation of ethanol spark ignition engine conversion.

LEARNING STEPS	RESOURCES
1. Read Resources 1A and 1B for an explanation of the current experimentation of ethanol engine conversion.	1. A. Magazine Article: "Mother's Experimental Alcohol-Powered Truck," Mother Earth News, pp. 78-82, in Learning Resources Center. B. Report: "Practical Experience with Pure Ethanol Engines--Brazil," Volkswagen Research, Special Hearing on Alcohol Fuels conducted by U.S. Senate Committee on Appropriations, January 31, 1978, in Learning Resources Center.
2. Read Resource 2A or 2B for a further explanation of the current experimentation of ethanol engine conversion.	2. A. Book: Brown's Alcohol Motor Fuel Cookbook, Brown, pp. 3-57, in Learning Resources Center. B. Book: Carburetion--Holley Carburetors, Emanuel, pp. 25-57, in Learning Resources Center.
3. Complete Resource 3 to practice explaining the current experimentation of ethanol engine conversion.	3. Activity Sheet 300-002-001: "Explain the Current Experimentation of Ethanol Spark Ignition Engine Conversion" in this Learning Guide.
4. Go to Resource 4 after Instructor approves Activity Sheet.	4. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

300-002-001

Explain the Current Experimentation of Ethanol Spark Ignition Engine Conversion

Using what you have learned from the reading assignments, explain in your own words the current experimentation of ethanol engine conversion by Brown, Mother Earth News, and Holley Corporation. Once you have finished, submit these written explanations to your instructor for approval.

MICRO-PERFORMANCE OBJECTIVE #3

Explain the major experimentation of ethanol spark ignition engine conversion.

LEARNING STEPS	RESOURCES
1. Review Resource 1 for an explanation of the major experimentation of ethanol engine conversion.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. Complete Resource 2 to compare the early experimentation of ethanol engine conversion to the current experimentation.	2. Activity Sheet 300-003-001: "Compare Early Experimentation of Ethanol Engine Conversion to Current Experimentation" in this Learning Guide.
3. Complete Resource 3 when you are ready to be evaluated on this objective.	3. Written Criterion Exam Task 300 from Instructor.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

ACTIVITY SHEET

300-003-001

Compare Early Experimentation of Ethanol Engine Conversion to Current Experimentation

Using what you have learned from the resources in Micro-Performance Objectives #1 and #2, compare the early experimentation of ethanol engine conversion to current experimentation. Once you have finished, submit your written comparisons to the instructor for approval.

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A LEARNING GUIDE

400

TASK Identify the modifications that must be made to the carburetion system of an ethanol spark ignition engine.

PURPOSE Carburetion is one of the major systems in which modifications are made in order to convert a spark ignition engine to ethanol. Before these modifications are made, the ethanol conversion technician identifies the specific areas within carburetion that must undergo modification and the procedures used to do these modifications.

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TERMINAL PERFORMANCE OBJECTIVE

Given a written criterion exam, identify the modifications that must be made to the carburetion system of an ethanol spark ignition engine. Mastery of this task will be shown by scoring 8 out of 10 or 80% on the exam.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Identify the modifications that must be made to the carburetion system of an ethanol spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Identify the modifications that must be made to the carburetion system of an ethanol spark ignition engine.

LEARNING STEPS	RESOURCES
1. View Resource 1 to identify the modifications that must be made to the carburetion system.	1. Slide/Tape Presentation 400-001-001: "Carburetion: Theory and Modifications for Alcohol Conversion." For information on obtaining the filmstrip version of this presentation write to: Illinois Vocational Curriculum Center Sangamon State University Springfield, Illinois 62708
2. Complete Resource 2 to practice identifying the modifications that must be made to the carburetion system.	2. Activity Sheet 400-001-002: "Identifying the Modifications to the Carburetion System" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to be evaluated on this objective, complete Resource 3.	3. Written Criterion Exam Task 400 from Instructor.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

ACTIVITY SHEET

400-001-002

Identifying the Modifications to the Carburetion System

Using what you have learned from the slide/tape presentation "Carburetion: Theory and Modifications for Alcohol Conversion," identify the major modifications that have to be made to the carburetion system of a spark ignition engine. Once you have finished, submit this activity sheet to your instructor for approval.

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A LEARNING GUIDE

401

TASK Construct and install an ethanol fuel preheater for a spark ignition engine.

PURPOSE In order for ethanol to vaporize successfully within the carburetor, the ethanol must be preheated in the fuel line to a temperature as close to 165°F as possible just before it enters the carburetor. The job of constructing and installing a fuel preheater is essential for the ethanol conversion technician to know.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate tools and materials, construct and install an ethanol fuel preheater for a spark ignition engine. Mastery of this task will be shown by obtaining 30 out of 30 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Construct an ethanol fuel preheater.

2. Install an ethanol fuel preheater.

3. Construct and install an ethanol fuel preheater.

MICRO-PERFORMANCE OBJECTIVE #1

Construct an ethanol fuel preheater.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how an ethanol fuel preheater is constructed.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice constructing an ethanol fuel preheater.	2. Activity Sheet 401-001-001: "Constructing an Ethanol Fuel Preheater" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

401-001-001

Constructing an Ethanol Fuel Preheater

Instructions: Complete the following operations.

1. Using a tape measure, select a piece of new copper pipe 4" in diameter and 1' in length. If necessary, use a hacksaw to cut a 1' length from a longer piece of pipe. The walls of the pipe should be 1/16" to 1/8" in thickness. (Although copper costs more than steel, copper is preferred because it conducts and retains heat better and is much easier to work with.)

2. Using a tape measure and a hacksaw, cut a rough circle 4 1/8" in diameter from a sheet of copper 1/16" to 1/8" in thickness.

3. Using a rotary file, trim the rough circle so that it is rounded and will completely cover the opening at one end of the copper pipe.

4. Using a soldering iron and acid core solder, attach the copper circle to the pipe so that the circle completely covers the opening at one end.

5. Using an outside micrometer, measure the diameter of the fuel line going into the carburetor.

6. Record this measurement.

7. Using a metal drill bit 1/16" larger than the diameter of the fuel line, make a hole in the center of the copper circle that now encloses the end of the copper pipe.

8. Using a hacksaw, cut a 3' length of copper tubing having the same diameter as the fuel line.

9. Using a copper tubing bender and a wood or metal rod approximately 3" in diameter and slightly less than 1' in length, wrap the copper tubing around the rod as many times as possible, leaving 4" to 6" of straight tubing (pigtails) at each end of the rod.

10. Slip the coiled tubing off of the rod.

11. Using an outside micrometer, measure the diameter of the return heater hose.

12. Using a metal drill bit having the same diameter as the heater hose, make two holes in the top of the copper pipe. The first hole should be 3" from one end of the pipe. The second hole should be 3" from the other end of the pipe.

13. Drill a third hole ½" in diameter in the top of the pipe 6" from the end of the pipe. Label the three holes A, B, and C starting from left to right.

14. Using a hacksaw, cut two pieces of copper tubing, each measuring 2" long and having the same diameter as the heater hose. Cut a third piece of copper tubing 2" long and ½" in diameter.

15. Using a soldering iron and acid core solder, attach these three 2" pieces of copper tubing to the holes corresponding in size that have been drilled in the top of the copper pipe. This will create nipples or adapters that the heater hose and a temperature gauge bulb can be connected to. Make sure that no gaps exist where the three 2" pieces of tubing are soldered to the holes in the pipe.

16. Using a metal file, smooth the rims of each 2" nipple.

17. Using a tape measure and a hacksaw, cut a rough circle 4 1/8" in diameter from a sheet of copper 1/16" to 1/8" in thickness.

18. Using a rotary file, trim the rough circle so that it is rounded and will completely cover the remaining opening of the pipe.

19. Using a metal drill bit 1/16" larger than the diameter of the fuel line, make a hole in the center of the copper circle.

20. Insert the coiled tubing into the copper pipe. Once the coil has entered the pipe, make sure the pigtail that was inserted first goes through the hole in the copper circle already soldered to the end of the pipe.

21. Slip the drilled-out copper circle not yet soldered to the pipe over the remaining pigtail of the coiled tubing.

22. Using a soldering iron and acid core solder, attach the copper circle to the pipe so that the circle completely covers the remaining opening.

23. Using a soldering iron and acid core solder, seal the gaps that exist between the holes in the copper circles and the pigtails of the copper tubing.

24. Fill the copper pipe with water to test for leaks. The pipe should be watertight. If not, locate the leak(s) and apply solder to them.

25. Ask your instructor for a copper tubing flaring kit. This kit should contain a copper tubing cutter, a reamer blade, a flaring bar, and a yoke assembly.

26. Using the copper tubing cutter, squarely cut 1/4" off the end of each pigtail.

27. Using the reamer blade of the tubing cutter, beburr the ends of the pigtails.

28. Measure the nut size of the fuel pump discharge fitting. Find a brass or steel nut of this size and slip it onto one of the pigtails.

29. Measure the nut size of the carburetor inlet fitting. Find a brass or steel nut of this size and slip it onto the other pigtail.

30. Place the end of one pigtail in the flaring bar so that 1/16" of the pigtail protrudes from the bar.

31. Using the yoke assembly, flare the end of the pigtail.

32. Place the end of the remaining pigtail in the flaring bar so that 1/16" of the pigtail protrudes from the bar.

33. Using the yoke assembly, flare the end of the pigtail.

34. Ask your instructor for a temperature gauge kit. This kit should contain a cable, a bulb, an adapter fitting, and a temperature indicator.*

35. Using a soldering iron and acid core solder, attach the temperature gauge adapter fitting to the nipple labeled B protruding from the copper pipe.

36. Slip the temperature gauge bulb (attached to the temperature gauge cable) through the adapter fitting until the bulb is completely submerged in the water contained in the copper pipe. Make sure that the bulb touches the water only and not the coil or the pipe.

37. Secure the bulb in position by screwing the adapter fitting nut (threaded on the temperature gauge cable) to the adapter fitting. This should make the fuel preheater totally watertight.

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* The temperature gauge will indicate to the driver the temperature of the water in the preheater warming the ethanol in the fuel line (165°F is ideal). When the temperature of the water reaches close to 173°F—the temperature at which ethanol vaporizes—the driver will reduce the amount of hot water flowing around the fuel line by engaging a water cutoff valve spliced into the inlet section of the return heater hose, thus reducing the temperature of the ethanol in the fuel line and avoiding a vaporlock.

MICRO-PERFORMANCE OBJECTIVE #2

Install an ethanol fuel preheater.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how an ethanol fuel preheater is installed.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice installing an ethanol fuel preheater.	2. Activity Sheet 401-002-001: "Installing an Ethanol Fuel Preheater" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

401-002-001

Installing an Ethanol Fuel Preheater

Instructions: Complete the following operations.

1. Using standard shop tools and equipment, construct an ethanol fuel preheater bracket. You will have to custom make this bracket to fit the particular type of engine and automobile you are working on: different types of engines will require different bracketing procedures. However, all brackets should be made of steel, and all brackets should be made to hold the ethanol fuel preheater securely. Use your ingenuity!

2. Ask the instructor for a spark ignition engine and automobile.

3. Using a screwdriver and metal screws, attach the bracket to a reinforced place near the engine (fender well, engine mount, etc.). You should make sure that once the fuel preheater is attached to the bracket, the preheater connections to the return heater hose, the fuel pump, and the carburetor can be made easily.

4. Attach the ethanol fuel preheater to the bracket.

5. Using a sharp knife, cut the return heater hose in half. Make sure you cut the hose so that the section coming from the engine (inlet hose) will fit easily on the copper nipple soldered to hole A or C, whichever is the closest. The section of hose going to the heater (outlet hose) should fit easily on the copper nipple soldered to the remaining hole.

6. Slip the two severed sections of heater hose on the nipples protruding from holes A and C.

7. Using heater hose clamps, secure the heater hose sections to the nipples.

8. Using the appropriate wrench, remove the existing fuel line going from the carburetor to the fuel pump.

9. Using the same wrench, connect the copper pigtail closest to the carburetor to the carburetor inlet fitting.

10. Connect the copper pigtail closest to the fuel pump to the fuel pump discharge fitting.

11. Using the appropriate tools, run the temperature gauge cable extending from hole B of the preheater to the dashboard of the automobile you are working on.

12. Attach the temperature gauge to dashboard.

13. Using a copper tubing cutter or a hacksaw, cut each copper pigtail in half. Then cut 1/8" off each of the severed ends of the pigtails.

14. Using the reamer blade of the tubing cutter or a metal file, deburr each end of the severed pigtails.

15. Using a sharp knife, cut two 3" pieces of rubber hose having a diameter slightly less than that of the pigtails.

16. Using the pieces of rubber hose, splice the severed sections of the pigtails. These splices allow the flexibility that is needed as the engine moves during operation.

17. Using hose clamps, secure the rubber hose splices to the copper pigtails.

18. Ask your instructor for a water regulating valve kit.

19. Using a sharp knife, cut in half the inlet section of the return heater hose going to the preheater from the engine.

20. Using standard shop tools, install the regulating valve as a splice between the severed ends of the inlet hose.

21. Once the regulating valve has been inserted, run the valve control cable to a convenient place on the dashboard of the automobile.

22. Attach the control cable to the dashboard.

MICRO-PERFORMANCE OBJECTIVE #3

Construct and install an ethanol fuel preheater.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to construct and install an ethanol fuel preheater.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your Instructor to administer Resource 2.	2. Product Checklist Task 401 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 401

		YES	NO
1.	Is the copper pipe that makes up the body of the fuel preheater 4" in diameter, 1' in length, and 1/16" to 1/8" in thickness?	( )	( )
2.	Are the copper circles enclosing the ends of the pipe 4 1/8" in diameter and 1/16" to 1/8" in thickness?	( )	( )
3.	After being trimmed, do the copper circles completely cover the openings at both ends of the pipe?	( )	( )
4.	Has the diameter of the fuel line going into the carburetor been measured correctly?	( )	( )
5.	Are the holes in the centers of the copper circles drilled to the correct size?	( )	( )
6.	Is the copper tubing coil constructed according to the correct dimensions, and is the coil wrapped properly?	( )	( )
7.	Has the diameter of the return heater hose been measured correctly?	( )	( )
8.	Have the three holes in the top of the copper pipe been measured, drilled, and labeled correctly?	( )	( )
9.	Have the copper nipples or adapters been measured, cut, and soldered correctly?	( )	( )
10.	Is the copper tubing coil inserted properly into the copper pipe?	( )	( )
11.	Are the gaps between the holes in the copper circles and the pigtails of the coil sealed properly?	( )	( )
12.	Is the copper pipe watertight?	( )	( )

Product Checklist Continued.

		YES	NO
13.	Are the ends of the copper pigtails cut, deburred, and flared properly?	( )	( )
14.	Has the nut size of the fuel pump discharge fitting been measured correctly?	( )	( )
15.	Has the nut size of the carburetor inlet fitting been measured correctly?	( )	( )
16.	Is the temperature gauge adapter fitting soldered properly to the copper nipple labeled B?	( )	( )
17.	Is the temperature gauge bulb and cable attached properly to the adapter fitting?	( )	( )
18.	Is the bulb completely submerged in the water contained in the copper pipe?	( )	( )
19.	Is the bulb suspended so that it touches only the water and not the coil or pipe?	( )	( )
20.	When holes A and C are plugged, is the fuel preheater totally watertight?	( )	( )
21.	Is the ethanol fuel preheater bracket functional?	( )	( )
22.	Is the bracket attached to a convenient and reinforced part of the automobile?	( )	( )
23.	Is the fuel preheater attached properly to the bracket?	( )	( )
24.	Is the return heater hose cut so that the ends fit easily on copper nipples A and C?	( )	( )
25.	Are the copper pigtails connected properly to the carburetor inlet fitting and the fuel pump discharge fitting?	( )	( )
26.	Does the temperature gauge cable extend to the dashboard of the automobile?	( )	( )

Product Checklist Continued.

		YES	NO
27.	Is the cable attached to a convenient place on the dashboard?	( )	( )
28.	Are the copper pigtails spliced properly with the rubber hose pieces?	( )	( )
29.	Is the water regulating valve installed correctly?	( )	( )
30.	Is the water valve control cable attached to a convenient place on the dashboard of the automobile?	( )	( )

Total Points	(30)			
Points Earned	( )			
Number Needed for Mastery	(30)			
Performance Attempt	1	2	3	4
Date of Attempt	___	___	___	___

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A LEARNING GUIDE

402

TASK Install a 190°F thermostat in the upper radiator hose of a spark ignition engine.

PURPOSE So that the water circulating in the fuel preheater is warm enough to heat the ethanol flowing through the copper tubing contained within the preheater to 165°F (desired temperature before fuel enters the carburetor), a 190°F thermostat is installed. This job is one of several dealing with vaporization that the ethanol conversion technician performs to make the engine run smoothly.

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TERMINAL PERFORMANCE OBJECTIVE

Given the appropriate tools, install a 190°F thermostat in the upper radiator hose of a spark ignition engine. Mastery of this task will be shown by obtaining 10 out of 10 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Install a 190°F thermostat in the upper radiator hose of a spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Install a 190°F thermostat in the upper radiator hose of a spark ignition engine.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how a thermostat in the upper radiator hose is installed.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice installing a thermostat in the upper radiator hose.	2. Activity Sheet 402-001-001: "Installing a Thermostat in the Upper Radiator Hose" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to perform this task without assistance, ask your Instructor to administer Resource 3.	3. Product Checklist Task 402 in this Learning Guide.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

ACTIVITY SHEET

402-001-001

Installing a Thermostat in the Upper Radiator Hose

Instructions: Complete the following operations.

1. Ask your instructor for a 190°F thermostat that will fit the engine you are working on.

2. Using standard shop tools, remove the upper radiator hose from the engine.

3. Locate the thermostat housing where the upper radiator hose goes into the engine block.

4. Using standard shop tools, remove the thermostat housing.

5. Remove the thermostat from the engine block.

6. Properly insert the new 190°F thermostat in the engine block.

7. Using standard shop tools, reinstall the thermostat housing on the engine block.

8. Using standard shop tools, reinstall the upper radiator hose.

PRODUCT CHECKLIST

Task 402

		YES	NO
1.	Was the instructor asked to provide a 190°F thermostat?	( )	( )
2.	Was the upper radiator hose removed properly?	( )	( )
3.	Was the thermostat housing located?	( )	( )
4.	Was the thermostat housing removed properly?	( )	( )
5.	Was the thermostat removed from the engine block properly?	( )	( )
6.	Was a new 190°F thermostat properly installed in the engine block?	( )	( )
7.	Was the thermostat housing properly reinstalled?	( )	( )
8.	Was the upper radiator hose properly reinstalled?	( )	( )
9.	Was the automobile started soon after the new thermostat was installed to check for water leaks?	( )	( )
10.	Was the water system of the automobile checked to determine if the new thermostat was functioning properly?	( )	( )

Total Points (10)

Points Earned ( )

Number Needed for Mastery (10)

Performance Attempt	1	2	3	4
Date of Attempt	____	____	____	____

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A LEARNING GUIDE

403

TASK Test the manifold temperature controls on a spark ignition engine.

PURPOSE So that the intake manifold and the engine will run warm enough under cold weather starting conditions allowing proper vaporization to take place in the carburetor, the manifold temperature control devices are tested for proper opening and closing. To prevent time-consuming delays, the ethanol conversion technician makes sure that these controls are operating properly before attempting to convert the engine.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate tools and equipment, test the manifold temperature controls on a spark ignition engine. Mastery of this task will be shown by obtaining 20 out of 20 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Test heat riser valve.
2. Test air inlet valve.
3. Test temperature sensing unit.
4. Test manifold temperature controls.

MICRO-PERFORMANCE OBJECTIVE #1

Test heat riser valve.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the heat riser valve is tested.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice testing the heat riser valve.	2. Activity Sheet 403-001-001: "Testing the Heat Riser Valve" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

403-001-001

Testing the Heat Riser Valve

Instructions: Complete the following operations.

1. Locate the heat riser valve at the end of the exhaust manifold.

2. Apply finger pressure to the counterweight of the heat riser valve until the counterweight can go no farther. Observe the reaction of the valve.

3. If the valve does not close completely and easily under finger pressure, check to see if there is rust or carbon deposits (build up) causing the counterweight to bind. Solve this problem by removing the rust or carbon.

4. Release finger pressure from the counterweight of the heat riser valve. Observe the reaction of the valve.

5. If the valve fails to open easily and completely when pressure is removed, check to see if the valve spring has lost its tension, if the spring is broken, or if the spring is missing. Solve these problems by replacing the spring.

MICRO-PERFORMANCE OBJECTIVE #2

Test air inlet valve.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the air inlet valve is tested.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice testing the air inlet valve.	2. Activity Sheet 403-002-001: "Testing the Air Inlet Valve" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

403-002-001

Testing the Air Inlet Valve

Instructions: Complete the following operations.

1. Remove the air cleaner from the engine.

2. Locate the air inlet valve on the air cleaner.

3. Apply finger pressure to the inlet valve flapper until it can go no farther. Observe the reaction of the flapper.

4. If the flapper does not close completely and easily under this pressure, check to see if rust or dirt buildup is present or if the flapper shaft is broken. Solve the problem either by removing the buildup or by replacing the shaft.

5. Release pressure from flapper. Observe the reaction of the flapper.

6. If the flapper fails to open completely and easily when pressure is withdrawn, check to see if the flapper spring has lost its tension or is broken. Solve the problem by replacing the spring.

7. Locate the vacuum motor on the air cleaner.

8. Connect a vacuum pump to the neck (vacuum fitting) of the vacuum motor and apply suction.

9. Observe the closing and opening action of the inlet valve flapper when the vacuum pump is turned on and off.

10. If the flapper does not close and open properly, repair or replace the vacuum motor.

11. Reinstall the air cleaner.

MICRO-PERFORMANCE OBJECTIVE #3

Test temperature sensing unit.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the temperature sensing unit is tested.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice testing the temperature sensing unit.	2. Activity Sheet 403-003-001: "Testing the Temperature Sensing Unit" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #4 in this Learning Guide.

ACTIVITY SHEET

403-003-001

Testing the Temperature Sensing Unit

Instructions: Complete the following operations.

1. Remove the air cleaner from the engine.

2. Locate the temperature sensing unit normally situated at the base of the air cleaner.

3. Apply a source of heat near the sensing unit until 125°F is reached. Use a thermometer to gauge the temperature.

4. Observe the reaction of the air inlet valve flapper when this temperature has been reached. If the temperature sensing unit is operating properly, it will feed into the air inlet valve causing the valve flapper to open. If the sensing unit is not operating properly, the flapper will remain closed.

5. If the sensing unit is not functioning properly, repair or replace it and the feeder line going to the air inlet valve.

6. Reinstall the air cleaner.

MICRO-PERFORMANCE OBJECTIVE #4

Test the manifold temperature controls on a spark ignition engine.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to test the manifold temperature controls on a spark ignition engine.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your Instructor to administer Resource 2.	2. Product Checklist Task 403 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 403

		YES	NO
1.	Was the heat riser valve located?	( )	( )
2.	Was finger pressure applied to the counterweight of the heat riser valve?	( )	( )
3.	Was the counterweight checked for rust and carbon deposits?	( )	( )
4.	Was finger pressure released from the counterweight?	( )	( )
5.	Was the counterweight checked for a faulty spring?	( )	( )
6.	Was the air cleaner removed properly?	( )	( )
7.	Was the air inlet valve of the air cleaner located?	( )	( )
8.	Was finger pressure applied to the inlet valve flapper?	( )	( )
9.	Was the flapper checked for rust and dirt?	( )	( )
10.	Was finger pressure released from the valve flapper?	( )	( )
11.	Was the flapper checked for a faulty spring?	( )	( )
12.	Was the vacuum motor of the air cleaner located?	( )	( )
13.	Was the vacuum motor tested by connecting a vacuum pump to the vacuum fitting?	( )	( )
14.	Was the vacuum motor repaired or replaced if it was not working properly?	( )	( )
15.	Was the temperature sensing unit of the air cleaner located?	( )	( )

Product Checklist Continued.

		YES	NO
16.	Was a source of heat applied near the sensing unit until 125°F was reached?	( )	( )
17.	Was a thermometer used to gauge the temperature?	( )	( )
18.	Was the sensing unit checked for proper operation by observing the valve flapper?	( )	( )
19.	Was the sensing unit repaired or replaced if it was not working properly?	( )	( )
20.	Was the air cleaner properly reinstalled?	( )	( )

Total Points	(20)			
Points Earned	( )			
Number Needed for Mastery	(20)			
Performance Attempt	1	2	3	4
Date of Attempt	_____	_____	_____	_____

SOUTHEASTERN ILLINOIS COLLEGE

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A LEARNING GUIDE

404

TASK Enlarge the areas of the idle circuit tubes in a carburetor for a spark ignition engine.

PURPOSE One of the most important things the ethanol conversion technician considers in the conversion process is the idle performance of the engine. To insure that the engine idles properly, the technician enlarges the areas of the idle circuit tubes in the carburetor.

In Cooperation with the Illinois State Board of Education
100 North First Street, Springfield, Illinois 62777

TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate measuring devices and tools, enlarge the areas of the idle circuit tubes in a carburetor for a spark ignition engine. Mastery of this task will be shown by scoring 8 out of 10 or 80% on a written criterion exam and by obtaining 20 out of 20 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Measure the diameter of each idle circuit tube.
2. Calculate the new area of each idle circuit tube.
3. Drill idle circuit tubes.
4. Enlarge the areas of the idle circuit tubes in a carburetor for a spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Measure the diameter of each idle circuit tube.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the diameter of an idle circuit tube is measured.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice measuring the diameter of an idle circuit tube.	2. Activity Sheet 404-001-001: "Measuring the Idle Circuit Tube Diameters" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

404-001-001

Measuring the Idle Circuit Tube Diameters

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine, engine overhaul tools, a set of numbered metal drill bits, and a 0"-1" outside micrometer.

2. Using standard overhaul procedures and tools, remove the carburetor from the engine.

3. Using standard overhaul procedures and tools, remove the venturi cluster from the carburetor. The venturi cluster contains the idle circuit tubes.

4. Select a metal drill bit that has the same diameter as the diameter of the hole in each idle circuit tube. If the drill bit is too small, it will wiggle around in the hole. If the drill bit is too large, it will not fit into the hole. The proper drill bit will fit snugly into the hole.

5. When you have found the correct drill bit, locate the number embossed on it. Refer to the drill bit holder or case for the size (diameter) that corresponds to this number. If the drill bit holder or case does not give sizes, use the 0"-1" outside micrometer to measure the diameter of the drill bit's shaft.

6. Make a note of the drill bit's number and diameter.

MICRO-PERFORMANCE OBJECTIVE #2

Calculate the new area of each idle circuit tube.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the new area of an idle circuit tube is calculated.	1. Instructor Demonstration performed in Classroom.
2. Complete Resource 2 to practice calculating the new area of an idle circuit tube.	2. Activity Sheet 404-002-001: "Calculating the New Areas of the Idle Circuit Tubes" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to be evaluated on this objective, complete Resource 3.	3. Written Criterion Exam Task 404 from Instructor.
4. Go to Resource 4 upon scoring 8 out of 10 or 80% on the exam.	4. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

404-002-001

Calculating the New Areas of the Idle Circuit Tubes

Instructions: Complete the following operations.

1. Locate the diameter of the drill bit (Activity Sheet 404-001-001, step #6) in the first column of the conversion table on the next page.

2. Across from this diameter in the last column of the table is the size (diameter) and number of the drill bit you will use to enlarge the diameters of the holes in the idle circuit tubes. Choose this drill bit from the set of numbered metal drill bits you are using.

3. If the exact diameter of the tube hole is not listed in the first column of the conversion table, use the following set of formulas to calculate the diameter of the drill bit you will need to enlarge the holes of the idle circuit tubes.

   1.) Perform this calculation to find the Area:

   $A = \pi \cdot r^2$

   A = Area
   π = pi = 3.14
   r = radius = ½ of diameter

   2.) Perform this calculation to find 40% of the Area:

   $.40 \cdot \text{Area} = 40\% \text{ of Area}$

   3.) Perform this calculation:

   $(40\% \text{ of Area} + \text{Area}) \div 3.14 = x$

   x = new Area

   4.) Perform this calculation:

   $\sqrt{x} \cdot 2$ = the diameter of the drill bit you need to enlarge the holes of the idle circuit tubes.

Activity Sheet Continued.

CONVERSION TABLE

IDLE TUBE DIAMETER	AREA	DIAMETER AND RECOMMENDED NUMBER OF DRILL BIT	
.022"	.0003799	.026023"	#71
.024"	.0004521	.028390"	#70
.026"	.0005306	.030757"	#68
.028"	.0006154	.033124"	#66
.030"	.0007065	.035496"	#65
.032"	.0008038	.037858"	#62
.034"	.0009074	.040224"	#60
.036"	.0010173	.042591"	#57
.038"	.0011335	.044958"	#56
.040"	.0012560	.047329"	#3/64
.042"	.0013847	.049691"	#55
.044"	.0015197	.052058"	#55
.046"	.0016610	.054424"	#54
.048"	.0018086	.056791"	#54
.050"	.0019625	.059161"	#53
.052"	.0021226	.061524"	#1/16
.054"	.0022890	.063890"	#52
.056"	.0024617	.066257"	#51
.058"	.0026407	.068624"	#50
.060"	.0028260	.070993"	#50
.062"	.0030175	.073357"	#49
.064"	.0032153	.075723"	#48
.066"	.0034194	.078090"	#5/64
.068"	.0036298	.080456"	#46

CONVERSION TABLE

IDLE TUBE DIAMETER	AREA	DIAMETER AND RECOMMENDED	NUMBER OF DRILL BIT
.070"	.0038465	.082825"	#45
.072"	.0040694	.085189"	#44
.074"	.0042986	.087556"	#43
.076"	.0045341	.089922"	#43
.078"	.0047759	.092289"	#42
.080"	.0050240	.094657"	#3/32
.082"	.0052783	.097022"	#40
.084"	.0055389	.099388"	#39

MICRO-PERFORMANCE OBJECTIVE #3

Drill idle circuit tubes.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the idle circuit tubes are drilled.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice drilling the idle circuit tubes.	2. Activity Sheet 404-003-001: "Drilling the Idle Circuit Tubes" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #4 in this Learning Guide.

ACTIVITY SHEET

404-003-001

Drilling the Idle Circuit Tubes

Instructions: Complete the following operations.

1. Ask the instructor for an electric drill motor and a bench vise.
2. Place the venturi cluster in the vise so that you are looking down into the idle circuit tubes.
3. Take the drill bit you selected in step #2 or calculated in step #3 of Activity Sheet 404-002-001 and fit it into the electric drill motor.
4. Enlarge the holes of the idle circuit tubes by drilling each hole to the size of the drill bit.
5. Remove the venturi cluster from the vise.
6. Using standard overhaul procedures and tools, place the venturi cluster back into the carburetor, reassemble the carburetor, and reattach the carburetor to the engine. (Note: Before you reassemble the carburetor and reattach it to the engine, it is a good idea to replace all exposed gaskets.)

MICRO-PERFORMANCE OBJECTIVE #4

Enlarge the areas of the idle circuit tubes in a carburetor for a spark ignition engine.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to enlarge the areas of the idle circuit tubes in a carburetor for a spark ignition engine.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your Instructor to administer Resource 2.	2. Product Checklist Task 404 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 404

		YES	NO
1.	Was the instructor asked to provide a spark ignition engine, engine overhaul tools, a set of numbered metal drill bits, and a 0"-1" outside micrometer?	( )	( )
2.	Was the carburetor properly removed from the engine?	( )	( )
3.	Was the venturi cluster properly removed from the carburetor?	( )	( )
4.	Were the idle circuit tubes located?	( )	( )
5.	Was a metal drill bit selected that has the same diameter as the hole in each idle circuit tube?	( )	( )
6.	Was the number that was embossed on the drill bit located?	( )	( )
7.	Were the number and diameter of the drill bit recorded?	( )	( )
8.	Was the diameter of the drill bit located in the first column of the conversion table?	( )	( )
9.	Were the diameter and number of the drill bit that will be used to enlarge the idle circuit tubes located in the last column of the conversion table?	( )	( )
10.	If the diameter of the tube holes was not listed in the first column of the table, was the diameter of the drill bit needed to enlarge the idle circuit tubes calculated?	( )	( )
11.	Was the area calculated correctly?	( )	( )
12.	Was 40% of the area calculated correctly?	( )	( )

Product Checklist Continued.

		YES	NO
13.	Was the new area calculated correctly?	( )	( )
14.	Was the diameter of the drill bit needed to enlarge the holes in the idle circuit tubes calculated correctly?	( )	( )
15.	Was the instructor asked to provide an electric drill motor and a bench vise?	( )	( )
16.	Was the venturi cluster placed in the vise so that the idle circuit tubes pointed upward?	( )	( )
17.	Was the drill bit that was selected to enlarge the idle circuit tubes inserted properly into the electric drill motor?	( )	( )
18.	Were the holes of the idle circuit tubes enlarged properly?	( )	( )
19.	Was the venturi cluster removed from the vise?	( )	( )
20.	Was the carburetor reassembled properly?	( )	( )

Total Points	(20)			
Points Earned	( )			
Number Needed for Mastery	(20)			
Performance Attempt	1	2	3	4
Date of Attempt	_____	_____	_____	_____

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A LEARNING GUIDE

405

TASK Enlarge the areas of the holes in the main jets of a carburetor for a spark ignition engine.

PURPOSE So that the proper air to fuel ratio is maintained in a carburetor using ethanol, the ethanol conversion technician enlarges the areas of the holes in the main jets.

In Cooperation with the Illinois State Board of Education
100 North First Street, Springfield, Illinois 62777

TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate measuring devices and tools, enlarge the areas of the holes in the main jets of a carburetor for a spark ignition engine. Mastery of this task will be shown by scoring 8 out of 10 or 80% on a written criterion exam and by obtaining 20 out of 20 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Measure the diameter of the hole in each of the main jets.
2. Calculate the new area of the hole in each of the main jets.
3. Drill holes of main jets.
4. Enlarge the areas of the holes in the main jets.

MICRO-PERFORMANCE OBJECTIVE #1

Measure the diameter of the hole in each of the main jets.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the diameter of the hole in a main jet is measured.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice measuring the diameter of the hole in a main jet.	2. Activity Sheet 405-001-001: "Measuring the Main Jet Holes" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

405-001-001

Measuring the Main Jet Holes

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine, engine overhaul tools, a set of numbered metal drill bits, and a 0"-1" outside micrometer.

2. Using standard overhaul procedures and tools, remove the carburetor from the engine.

3. Using standard overhaul procedures and tools, disassemble the carburetor to a point where the main jets can be removed.

4. Remove the main jets from the carburetor.

5. Select a metal drill bit that has the same diameter as the diameter of the hole in each jet. If the drill bit is too small, it will wiggle around in the hole. If the drill bit is too large, it will not fit into the hole. The proper drill bit will fit snugly into the hole.

6. When you have found the correct drill bit, locate the number embossed on it. Refer to the drill bit holder or case for the size (diameter) that corresponds to this number. If the drill bit holder or case does not give sizes, use the 0"-1" outside micrometer to measure the diameter of the drill bit's shaft.

7. Make a note of the drill bit's number and diameter.

MICRO-PERFORMANCE OBJECTIVE #2

Calculate the new area of the hole in each of the main jets.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the new area of the hole in a main jet is calculated.	1. Instructor Demonstration performed in Classroom.
2. Complete Resource 2 to practice calculating the new area of the hole in a main jet.	2. Activity Sheet 405-002-001: "Calculating the New Areas of the Main Jet Holes" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to be evaluated on this objective, complete Resource 3.	3. Written Criterion Exam Task 405 from Instructor.
4. Go to Resource 4 upon scoring 8 out of 10 or 80% on the exam.	4. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

405-002-001

Calculating the New Areas of the Main Jet Holes

Instructions: Complete the following operations.

1. Locate the diameter of the drill bit (Activity Sheet 405-001-001, step #7) in the first column of the conversion chart on the next page.

2. Across from this diameter in the last column of the chart is the size (diameter) and number of the drill bit you will use to enlarge the diameters of the holes in the main jets. Choose this drill bit from the set of numbered metal drill bits you are using.

3. If the exact size of the jet hole's diameter is not listed in the conversion chart, use the following set of formulas to calculate the diameter of the drill bit you will need to enlarge the holes of the main jets.

   1.) Perform this calculation to find the Area:

   $A = \pi \cdot r^2$

   A = Area
   π = pi = 3.14
   r = radius = $\frac{1}{2}$ of diameter

   2.) Perform this calculation to find 40% of the Area:

   $.40 \cdot \text{Area} = 40\% \text{ of Area}$

   3.) Perform this calculation:

   $(40\% \text{ of Area} + \text{Area}) \div 3.14 = x$

   x = new Area

   4.) Perform this calculation:

   $\sqrt{x} \cdot 2$ = the diameter of the drill bit you need to enlarge the holes in the main jets.

Activity Sheet Continued.

CONVERSION TABLE

JET HOLE DIAMETER	AREA	DIAMETER AND RECOMMENDED NUMBER OF DRILL BIT	
.022"	.003799	.026023"	#71
.024"	.004521	.028390"	#70
.026"	.005306	.030757"	#68
.028"	.0006154	.033124"	#66
.030"	.0007065	.035496"	#65
.032"	.0008038	.037858"	#62
.034"	.0009074	.040224"	#60
.036"	.0010173	.042591"	#57
.038"	.0011335	.044958"	#56
.040"	.0012560	.047329"	#3/64
.042"	.0013847	.049691"	#55
.044"	.0015197	.052058"	#55
.046"	.0016610	.054424"	#54
.048"	.0018086	.056791"	#54
.050"	.0019625	.059161"	#53
.052"	.0021226	.061524"	#1/16
.054"	.0022890	.063890"	#52
.056"	.0024617	.066257"	#51
.058"	.0026407	.068624"	#50
.060"	.0028260	.070993"	#50
.062"	.0030175	.073357"	#49
.064"	.0032153	.075723"	#48
.066"	.0034194	.078090"	#5/64
.068"	.0036298	.080456"	#46

Activity Sheet Continued.

CONVERSION TABLE

JET HOLE DIAMETER	AREA	DIAMETER AND RECOMMENDED	NUMBER OF DRILL BIT
.070"	.0038465	.082825"	#45
.072"	.0040694	.085189"	#44
.074"	.0042986	.087556"	#43
.076"	.0045341	.089922"	#43
.078"	.0047759	.092289"	#42
.080"	.0050240	.094657"	#3/32
.082"	.0052783	.097022"	#40
.084"	.0055389	.099388"	#39

MICRO-PERFORMANCE OBJECTIVE #3

Drill holes of main jets.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the holes of the main jets are drilled.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice drilling the holes of the main jets.	2. Activity Sheet 405-003-001: "Drilling the Main Jet Holes" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #4 in this Learning Guide.

ACTIVITY SHEET

405-003-001

Drilling the Main Jet Holes

Instructions: Complete the following operations.

1. Ask the instructor for an electric drill motor and a bench vise.

2. Place the main jets in the vise so that you are looking down into the holes.

3. Take the drill bit you selected in step #2 or calculated in step #3 of Activity Sheet 405-002-001 and fit it into the electric drill motor.

4. Enlarge the holes of the main jets by drilling each jet hole to the size of the drill bit.

5. Remove the jets from the vise.

6. Using standard overhaul procedures and tools, place the jets back into the carburetor, reassemble the carburetor, and reattach the carburetor to the engine. (Note: Before you reassemble the carburetor and reattach it to the engine, it is a good idea to replace all exposed gaskets.)

MICRO-PERFORMANCE OBJECTIVE #4

Enlarge the areas of the holes in the main jets.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to enlarge the areas of the holes in the main jets.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your Instructor to administer Resource 2.	2. Product Checklist Task 405 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 405

		YES	NO
1.	Was the instructor asked to provide a spark ignition engine, engine overhaul tools, a set of numbered metal drill bits, and a 0"-1" outside micrometer?	( )	( )
2.	Was the carburetor removed properly from the engine?	( )	( )
3.	Was the carburetor disassembled to a point where the main jets could be removed?	( )	( )
4.	Were the main jets removed properly from the carburetor?	( )	( )
5.	Was a metal drill bit selected that has the same diameter as the diameter of the hole in each jet?	( )	( )
6.	Was the number that was embossed on the drill bit located?	( )	( )
7.	Were the number and diameter of the drill bit recorded?	( )	( )
8.	Was the diameter of the drill bit located in the first column of the conversion table?	( )	( )
9.	Were the diameter and number of the drill bit that will be used to enlarge the main jet holes located in the last column of the conversion table?	( )	( )
10.	If the diameter of the jet holes was not listed in the first column of the table, was the diameter of the drill bit needed to enlarge the jet holes calculated?	( )	( )
11.	Was the area calculated correctly?	( )	( )

Product Checklist Continued.

		YES	NO
12.	Was 40% of the area calculated correctly?	( )	( )
13.	Was the new area calculated correctly?	( )	( )
14.	Was the diameter of the drill bit needed to enlarge the main jet holes calculated correctly?	( )	( )
15.	Was the instructor asked to provide an electric drill motor and a bench vise?	( )	( )
16.	Were the main jets placed in the vise so that the holes pointed upward?	( )	( )
17.	Was the drill bit that was selected to enlarge the jet holes inserted properly into the electric drill motor?	( )	( )
18.	Were the main jet holes enlarged properly?	( )	( )
19.	Were the main jets removed from the vise?	( )	( )
20.	Was the carburetor reassembled properly?	( )	( )

Total Points	(20)			
Points Earned	( )			
Number Needed for Mastery	(20)			
Performance Attempt	1	2	3	4
Date of Attempt	______	______	______	______

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A LEARNING GUIDE

406

TASK Raise the level of fuel in the fuel bowl of a carburetor for a spark ignition engine.

PURPOSE Because ethanol as a fluid is heavier than gasoline, the level of ethanol in the fuel bowl must be raised if the carburetor is to work correctly. By raising the level of fuel in the bowl, one can maintain the proper air to fuel ratio in the carburetor. This job is a basic conversion operation that the ethanol conversion technician performs.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate measuring devices and tools, raise the level of fuel in the fuel bowl of a carburetor for a spark ignition engine. Mastery of this task will be shown by obtaining 30 out of 30 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Raise the fuel level in the fuel bowl by adjusting the float screw.

2. Raise the fuel level in the fuel bowl by increasing the weight of the float.

3. Raise the level of fuel in the fuel bowl of a carburetor.

MICRO-PERFORMANCE OBJECTIVE #1

Raise the fuel level in the fuel bowl by adjusting the float screw.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the fuel level in the fuel bowl is raised by adjusting the float screw.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice raising the fuel level in the fuel bowl by adjusting the float screw.	2. Activity Sheet 406-001-001: "Adjusting the Float Screw" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

406-001-001

Adjusting the Float Screw

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine, engine overhaul tools, and a 6" steel rule.

2. Using standard overhaul procedures and tools, remove the carburetor from the engine.

3. Using standard overhaul procedures and tools, disassemble the carburetor far enough so that the fuel bowl and the fuel float are exposed.

4. Using the steel rule, measure the level of fuel in the fuel bowl.

5. Calculate a level 10% higher than the level of fuel in the bowl: 1.10 x level of fuel in bowl = 10% level increase.

6. Using the steel rule, indicate this new height on the fuel bowl wall with a pencil mark.

7. Locate the adjustable fuel float screw.

8. Using a screwdriver, adjust the screw so that the fuel in the bowl rises to the level indicated by the pencil mark.

9. Using standard overhaul procedures and tools, reassemble the carburetor and reattach it to the engine. (Note: Before you reassemble the carburetor and reattach it to the engine, it is a good idea to replace all exposed gaskets.)

MICRO-PERFORMANCE OBJECTIVE #2

Raise the fuel level in the fuel bowl by increasing the weight of the float.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the fuel level in the fuel bowl is raised by increasing the weight of the float.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice raising the fuel level in the fuel bowl by increasing the weight of the float.	2. Activity Sheet 406-002-001: "Increasing the Weight of the Float" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

406-002-001

Increasing the Weight of the Float

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine, engine overhaul tools, a gram scale, a soldering iron, acid core solder, and a 6" steel rule.

2. Using standard overhaul procedures and tools, remove the carburetor from the engine.

3. Using standard overhaul procedures and tools, disassemble the carburetor far enough so that the fuel float can be removed.

4. Using the steel rule, measure the level of fuel in the fuel bowl.

5. Calculate a level 10% higher than the level of fuel in the bowl: 1.10 x level of fuel in bowl = 10% level increase.

6. Using standard overhaul procedures and tools, remove the fuel float from the carburetor.

7. Wash the fuel float with soap and water. Wipe dry.

8. Weigh float on the gram scale.

9. Calculate 10% of the float's weight: .10 x weight of float = 10% of float's weight. Remove the float from the gram scale.

10. Weigh enough acid core solder on the gram scale until you get 10% of the float's weight. Most floats are brass; however, if the float is plastic, find a steel washer and a piece of wire that add up to 10% of the float's weight.

11. Apply solder flux to the top of the float. If the float is plastic, disregard this step.

12. Using the soldering iron, apply the acid core solder obtained in step #10 of this activity sheet to the top of the float. If the float is plastic, wire the washer obtained in step #10 to the float.

13. Let solder cool.

14. Weigh the float on the gram scale to see that the float's original weight has indeed been increased by 10%.

15. Wash the float with soap and water. Wipe dry.

16. Reinstall the float in the carburetor.

17. Using the steel rule, measure the level of fuel in the fuel bowl. This level should match the height calculated in step #5 of this activity sheet.

18. Using standard overhaul procedures and tools, reassemble the carburetor and reattach it to the engine. (Note: Before you reassemble the carburetor and reattach it to the engine, it is a good idea to replace all exposed gaskets.)

MICRO-PERFORMANCE OBJECTIVE #3

Raise the level of fuel in the fuel bowl of a carburetor.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to raise the level of fuel in the fuel bowl of a carburetor.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your Instructor to administer Resource 2.	2. Product Checklist Task 406 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 406

		YES	NO
1.	Was the instructor asked to provide a spark ignition engine, engine overhaul tools, and a 6" steel rule?	( )	( )
2.	Was the carburetor removed properly from the engine?	( )	( )
3.	Was the carburetor disassembled far enough so that the fuel bowl and fuel float were exposed?	( )	( )
4.	Was the level of fuel in the fuel bowl measured correctly?	( )	( )
5.	Was a level 10% higher than the level of fuel in the fuel bowl calculated correctly?	( )	( )
6.	Was this new height indicated on the fuel bowl wall?	( )	( )
7.	Was the adjustable fuel float screw located?	( )	( )
8.	Was the fuel float screw adjusted so that the fuel in the bowl rose to the level indicated on the fuel bowl wall?	( )	( )
9.	Was the instructor asked to provide a gram scale, soldering iron, and acid core solder?	( )	( )
10.	Was the fuel float removed properly from the carburetor?	( )	( )
11.	Was the fuel float washed with soap and water?	( )	( )
12.	Was the fuel float wiped dry?	( )	( )
13.	Was the fuel float weighed correctly on a gram scale?	( )	( )

Product Checklist Continued.

	YES	NO
14. Was 10% of the fuel float's weight calculated correctly?	☐	☐
15. Was the fuel float removed from the gram scale?	☐	☐
16. Was enough acid core solder weighed on the gram scale to equal 10% of the fuel float's weight?	☐	☐
17. Was the fuel float determined to be brass or plastic?	☐	☐
18. If the float was plastic, was a steel washer and a piece of wire obtained that added up to 10% of the float's weight?	☐	☐
19. If the fuel float was brass, was solder flux applied to the top of the float?	☐	☐
20. Was the acid core solder that added up to 10% of the fuel float's weight applied to the top of the float?	☐	☐
21. Was the solder allowed to cool?	☐	☐
22. Was the fuel float weighed on the gram scale to see if the original weight of the float was increased by 10%?	☐	☐
23. Was the fuel float washed with soap and water?	☐	☐
24. Was the fuel float wiped dry?	☐	☐
25. If the fuel float was plastic, were the steel washer and piece of wire connected properly to the float?	☐	☐
26. Was the fuel float reinstalled properly in the carburetor?	☐	☐
27. Did the new weight of the fuel float represent a 10% increase in the level of fuel in the fuel bowl?	☐	☐

Product Checklist Continued.

		YES	NO
28.	Was the carburetor reassembled properly?	( )	( )
29.	Was the carburetor reattached properly to the engine?	( )	( )
30.	Was the engine started to check for proper working order?	( )	( )

Total Points	(30)			
Points Earned	( )			
Number Needed for Mastery	(30)			
Performance Attempt	1	2	3	4
Date of Attempt	_____	_____	_____	_____

SOUTHEASTERN ILLINOIS COLLEGE

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A LEARNING GUIDE

500

TASK Install high compression ratio pistons in a spark ignition engine.

PURPOSE To get the maximum power from the push at the top of each piston in a spark ignition engine operating on ethanol, the ethanol conversion technician takes advantage of the fuel's low BTU/gal. level and high octane rating by installing high compression pistons.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate tools and equipment, install high compression ratio pistons in a spark ignition engine. Mastery of this task will be shown by obtaining 30 out of 30 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Install high compression ratio pistons in a spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Install high compression ratio pistons in a spark ignition engine.

LEARNING STEPS	RESOURCES
1. View Resource 1 to identify the modification that must be made to the compression system of a spark ignition engine.	1. Slide/Tape Presentation 500-001-001: "Compression: Theory and Modification for Alcohol Conversion." For information on obtaining the filmstrip version of this presentation write to: Illinois Vocational Curriculum Center Sangamon State University Springfield, Illinois 62708
2. View Resource 2 to observe how high compression ratio pistons are installed.	2. Instructor Demonstration performed in Lab.
3. Complete Resource 3 to practice installing high compression ratio pistons.	3. Activity Sheet 500-001-002: "Installing High Compression Ratio Pistons" in this Learning Guide.
4. After the Instructor approves the Activity Sheet and when you are ready to perform this task without assistance, ask your Instructor to administer Resource 4.	4. Product Checklist Task 500 in this Learning Guide.
5. See Resource 5 to begin next Learning Guide.	5. Instructor.

ACTIVITY SHEET

500-001-002

Installing High Compression Ratio Pistons

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine, engine overhaul tools and equipment, 12:1 compression ratio pistons, and pin press adapters.

2. Using standard overhaul procedures and tools, disassemble the engine far enough so that the pistons and connecting rods can be removed.

3. Using standard overhaul procedures and tools, remove the pistons and the connecting rods from the engine.

4. Examine the crankshaft for wear, out of round, scoring, etc. If the crankshaft is in good condition, proceed to step #5. If the crankshaft needs to be repaired or replaced, refer to the engine manufacturer's service manual for instructions.

5. Examine engine cylinders for scoring, taper, out of round, etc. If cylinders are in good condition, proceed to step [illegible]6. If cylinders need to be repaired or replaced, refer to the engine manufacturer's service manual for instructions.

6. Using standard overhaul procedures and tools, hone the cylinders to remove the glaze and to obtain a crosshatch pattern. This insures proper ring wear-in.

7. Using standard overhaul procedures and tools, separate pistons from connecting rods by removing the piston pins.

8. Examine the rods for evidence of bending, twisting, and bearing movement. If the rods are in good condition, proceed to step #9. If the rods need to be repaired or replaced, refer to the engine manufacturer's service manual for instructions.

9. Press new 12:1 compression ratio pistons and pin assemblies on rods. Use the proper pin press adapters to prevent piston and rod distortion and breakage. (Note: This step and all the remaining steps of this activity sheet require the use of standard overhaul procedures and tools.)

10. Install rings on the pistons.

11. Lubricate rings and pistons generously with engine oil.

12. Install new rod bearings.

13. Install rod and piston assemblies into engine block.

14. Check for proper bearing clearance by using plastigage.

15. Remove all evidence of plastigage from crankshaft and rod bearings.

16. Install rod caps on respective rods and tighten bolts to proper torque specifications (refer to engine manufacturer's service manual for specifications).

17. Install new oil pan gasket on oil pan.

18. Perform a valve grind job on cylinder heads.

19. Install new steel cylinder head gaskets.

20. Install heads on engine by tightening head bolts according to engine manufacturer's recommended sequence and torque specifications.

21. Remove all carbon deposits from the exhaust heat crossover passageways of the intake manifold.

22. Remove the thin metal shield (heat baffle) attached to the underside of the intake manifold.

23. Clean the shield of all carbon deposits.

24. Clean the manifold of all carbon deposits.

25. Reattach the shield to the manifold by using sheet metal screws or rivets.

26. Install manifold on engine.

PRODUCT CHECKLIST

Task 500

		YES	NO
1.	Was the instructor asked to provide a spark ignition engine, engine overhaul tools and equipment, 12:1 compression ratio pistons, and pin press adapters?	( )	( )
2.	Was the engine disassembled far enough so that the pistons and connecting rods were exposed?	( )	( )
3.	Were the pistons removed properly?	( )	( )
4.	Were the connecting rods removed properly?	( )	( )
5.	Was the crankshaft inspected for wear, out of round, and scoring?	( )	( )
6.	Were the engine's cylinders inspected for scoring, taper, and out of round?	( )	( )
7.	Were the cylinders honed to remove glaze and to obtain a crosshatch pattern?	( )	( )
8.	Were the pistons separated properly from the connecting rods?	( )	( )
9.	Were the connecting rods inspected for bends, twists, and bearing movement?	( )	( )
10.	Were new 12:1 compression ratio pistons and pin assemblies pressed properly on the connecting rods?	( )	( )
11.	Were the correct pin press adapters used?	( )	( )
12.	Were rings installed properly on the pistons?	( )	( )
13.	Were the rings and pistons lubricated generously with engine oil?	( )	( )

Product Checklist Continued.

		YES	NO
14.	Were new rod bearings installed properly?	( )	( )
15.	Were rod and piston assemblies installed properly in the engine block?	( )	( )
16.	Was proper bearing clearance checked by using plastigage?	( )	( )
17.	Was all evidence of plastigage removed from crankshaft?	( )	( )
18.	Was all evidence of plastigage removed from rod bearings?	( )	( )
19.	Were rod caps installed on respective rods and bolts tightened to proper torque specifications?	( )	( )
20.	Was a new oil pan gasket installed properly on the oil pan?	( )	( )
21.	Was a valve grind job performed properly on the cylinder heads?	( )	( )
22.	Were new steel cylinder head gaskets installed properly?	( )	( )
23.	Were heads installed properly on engine?	( )	( )
24.	Were head bolts tightened according to engine manufacturer's recommended sequence and torque specifications?	( )	( )
25.	Were all carbon deposits removed from the exhaust heat crossover passageways of the intake manifold?	( )	( )
26.	Was the heat baffle removed from the underside of the intake manifold?	( )	( )
27.	Were all carbon deposits removed from the heat baffle?	( )	( )

Product Checklist Continued.

		YES	NO
28.	Was the manifold cleaned properly?	( )	( )
29.	Was the heat baffle reattached to the manifold by using sheet metal screws or rivets?	( )	( )
30.	Was the manifold installed properly on the engine?	( )	( )

Total Points	(30)			
Points Earned	( )			
Number Needed for Mastery	(30)			
Performance Attempt	1	2	3	4
Date of Attempt	_____	_____	_____	_____

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A LEARNING GUIDE

600

TASK Identify the modifications that must be made to the ignition system of an ethanol spark ignition engine.

PURPOSE Ignition is one of the major systems in which modifications are made in order to convert a spark ignition engine to ethanol. Before these modifications are made, the ethanol conversion technician identifies the specific areas within ignition that must undergo modification and the procedures used to do these modifications.

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TERMINAL PERFORMANCE OBJECTIVE

Given a written criterion exam, identify the modifications that must be made to the ignition system of an ethanol spark ignition engine. Mastery of this task will be shown by scoring 4 out of 5 or 80% on the exam.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Identify the modifications that must be made to the ignition system of an ethanol spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Identify the modifications that must be made to the ignition system of an ethanol spark ignition engine.

LEARNING STEPS	RESOURCES
1. View Resource 1 to identify the modifications that must be made to the ignition system.	1. Slide/Tape Presentation 600-001-001: "Ignition: Theory and Modifications for Alcohol Conversion." For information on obtaining the filmstrip version of this presentation write to: Illinois Vocational Curriculum Center Sangamon State University Springfield, Illinois 62708
2. Complete Resource 2 to practice identifying the modifications that must be made to the ignition system.	2. Activity Sheet 600-001-002: "Identifying the Modifications to the Ignition System" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to be evaluated on this objective, complete Resource 3.	3. Written Criterion Exam Task 600 from Instructor.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

ACTIVITY SHEET

600-001-002

Identifying the Modifications to the Ignition System

Using what you have learned from the slide/tape presentation "Ignition: Theory and Modifications for Alcohol Conversion," identify the major modifications that must be made to the ignition system of a spark ignition engine. Once you have finished, submit this activity sheet to your instructor for approval.

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A LEARNING GUIDE

601

TASK Advance the initial timing of the distributor of a spark ignition engine.

PURPOSE Because ethanol burns slower than gasoline, the timing of the distributor should be advanced. By doing this, the ethanol conversion technician gets even more push out of each piston. The results, of course, mean engine efficiency to the conversion technician's customers.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate tools, equipment, and service manual, advance the initial timing of the distributor of a spark ignition engine. Mastery of this task will be shown by obtaining 5 out of 5 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Advance the initial timing of the distributor of a spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Advance the initial timing of the distributor of a spark ignition engine.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the initial timing of a distributor is advanced.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice advancing the initial timing of a distributor.	2. Activity Sheet 601-001-001: "Advancing the Initial Timing of a Distributor" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to perform this task without assistance, ask your Instructor to administer Resource 3.	3. Product Checklist Task 601 in this Learning Guide.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

ACTIVITY SHEET

601-001-001

Advancing the Initial Timing of a Distributor

Instructions: Complete the following operations.

1. Ask your instructor for a spark ignition engine, a distributor tester, and a timing light.
2. Using the distributor tester, test the engine's distributor for proper working order and accuracy.
3. Determine the normal timing specifications for the engine by referring to the engine manufacturer's service manual.
4. Connect the timing light to No. 1 spark plug.
5. Rotate the distributor until the timing light indicates that the initial timing has been advanced 4° ahead of factory specifications.
6. Disconnect the timing light.

PRODUCT CHECKLIST

Task 601

	YES	NO
1. Was the engine's distributor tested for proper working order and accuracy?	( )	( )
2. Were the normal timing specifications for the engine determined by referring to the engine manufacturer's service manual?	( )	( )
3. Was the timing light connected to No. 1 spark plug?	( )	( )
4. Was the distributor rotated until the timing light indicated that the initial timing had been advanced 4° ahead of factory specifications?	( )	( )
5. Was the timing light disconnected?	( )	( )

Total Points	(5)			
Points Earned	( )			
Number Needed for Mastery	(5)			
Performance Attempt	1	2	3	4
Date of Attempt	_____	_____	_____	_____

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A LEARNING GUIDE

602

TASK Select, gap, and install higher heat range spark plugs in a spark ignition engine.

PURPOSE Since ethanol burns cooler than gasoline, the converted engine will show better ignition performance if spark plugs with a higher heat range are installed and if the spark plug gaps are widened. The ethanol conversion technician does this operation to insure better engine efficiency for the customer.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate measuring devices, tools, and service manual select, gap, and install higher heat range spark plugs in a spark ignition engine. Mastery of this task will be shown by obtaining 10 out of 10 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Select spark plugs.
2. Gap spark plugs.
3. Install spark plugs.
4. Select, gap, and install higher heat range spark plugs.

MICRO-PERFORMANCE OBJECTIVE #1

Select spark plugs.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the higher heat range spark plugs are selected.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice selecting the higher heat range spark plugs.	2. Activity Sheet 602-001-001: "Selecting Higher Heat Range Spark Plugs" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #2 in this Learning Guide.

ACTIVITY SHEET

602-001-001

Selecting Higher Heat Range Spark Plugs

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine.
2. Determine the suggested heat range of the spark plugs used in the engine by referring to factory specifications in the engine manufacturer's service manual.
3. Determine the heat range of spark plugs two ranges hotter or higher than factory specifications.
4. Obtain these plugs from your instructor.

MICRO-PERFORMANCE OBJECTIVE #2

Gap spark plugs.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the higher heat range spark plugs are gapped.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice gapping the higher heat range spark plugs.	2. Activity Sheet 602-002-001: "Gapping Higher Heat Range Spark Plugs" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #3 in this Learning Guide.

ACTIVITY SHEET

602-002-001

Gapping Higher Heat Range Spark Plugs

Instructions: Complete the following operations.

1. Determine the suggested size of the spark gap for plugs used in the engine by referring to factory specifications in the engine manufacturer's service manual.

2. Calculate a size .002" wider than factory specifications.

3. Using a spark plug gap gauge, gap the hotter plugs selected in Activity Sheet 602-001-001 to this wider size.

MICRO-PERFORMANCE OBJECTIVE #3

Install spark plugs.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how the higher heat range spark plugs are installed.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice installing the higher heat range spark plugs.	2. Activity Sheet 602-003-001: "Installing Higher Heat Range Spark Plugs" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #4 in this Learning Guide.

ACTIVITY SHEET

602-003-001

Installing Higher Heat Range Spark Plugs

Instructions: Complete the following operations.

1. Using the appropriate tools, remove the old spark plugs from the engine.

2. Replace these plugs with the new spark plugs obtained in Activity Sheets 602-001-001 and 602-002-001.

3. Attach spark plug wires.

MICRO-PERFORMANCE OBJECTIVE #4

Select, gap, and install higher heat range spark plugs.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to select, gap, and install higher heat range spark plugs.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your instructor to administer Resource 2.	2. Product Checklist Task 602 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 602

		YES	NO
1.	Was the instructor asked to provide a spark ignition engine?	( )	( )
2.	Was the recommended heat range of the engine's spark plugs determined by referring to the engine manufacturer's service manual?	( )	( )
3.	Was the heat range of spark plugs two ranges hotter than factory specifications calculated correctly?	( )	( )
4.	Were these hotter spark plugs obtained from the instructor?	( )	( )
5.	Was the recommended size of the spark gap for the normal spark plugs determined by referring to the engine manufacturer's service manual?	( )	( )
6.	Was a size .002" wider than factory specifications calculated correctly?	( )	( )
7.	Were the hotter spark plugs gapped to this wider size?	( )	( )
8.	Were the old spark plugs removed properly from the engine?	( )	( )
9.	Were the old spark plugs replaced properly with the new hotter spark plugs?	( )	( )
10.	Were the spark plug wires attached properly to the spark plugs?	( )	( )

Total Points	(10)			
Points Earned	( )			
Number Needed for Mastery	(10)			
Performance Attempt	1	2	3	4
Date of Attempt	____	____	____	____

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A LEARNING GUIDE

700

TASK Install a high torque starter in a spark ignition engine.

PURPOSE Because the converted engine has a higher compression ratio and the ignition timing has been advanced, the engine requires more power to start. To get quick starting performance, the ethanol conversion technician installs a high torque starter.

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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate tools, install a high torque starter in a spark ignition engine. Mastery of this task will be shown by obtaining 5 out of 5 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Install a high torque starter in a spark ignition engine.

MICRO-PERFORMANCE OBJECTIVE #1

Install a high torque starter in a spark ignition engine.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how a high torque starter is installed.	1. Instructor Demonstration performed in Lab.
2. Complete Resource 2 to practice installing a high torque starter.	2. Activity Sheet 700-001-001: "Installing a High Torque Starter in a Spark Ignition Engine" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to perform this task without assistance, ask your Instructor to administer Resource 3.	3. Product Checklist Task 700 in this Learning Guide.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

ACTIVITY SHEET

700-001-001

Installing a High Torque Starter in a Spark Ignition Engine

Instructions: Complete the following operations.

1. Ask the instructor for a spark ignition engine.

2. Using standard overhaul procedures and tools, remove the starter from the engine.

3. Find the torque specifications (ft. lbs.) of the removed starter in the engine manufacturer's service manual.

4. Calculate the torque specifications of a starter using a third more ft. lbs. than the removed starter. For example: 100 ft. lbs. x 1.333 = a starter with a third more ft. lbs.

5. Using standard overhaul procedures and tools, install in the engine a starter with a third more ft. lb. capacity than the removed starter.

PRODUCT CHECKLIST

Task 700

		YES	NO
1.	Was the instructor asked to provide a spark ignition engine?	( )	( )
2.	Was the starter removed properly from the engine?	( )	( )
3.	Were the torque specifications for the starter determined by referring to the engine manufacturer's service manual?	( )	( )
4.	Were the torque specifications for a starter using a third more ft. lbs. calculated properly?	( )	( )
5.	Was the starter with a third more ft. lbs. installed properly?	( )	( )

Total Points	(5)			
Points Earned	( )			
Number Needed for Mastery	(5)			
Performance Attempt	1	2	3	4
Date of Attempt	____	____	____	____

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A LEARNING GUIDE

800

TASK Test and analyze a spark ignition engine converted to ethanol.

PURPOSE In order to check the efficiency of a converted engine, the ethanol conversion technician performs basic tests on the engine and analyzes the results. From the findings, the conversion technician determines what changes, if any, need to be made to the engine. The successful person in the ethanol engine conversion business returns to the customer a vehicle that performs as well as, if not better than, it did while operating on gasoline.

In Cooperation with the Illinois State Board of Education
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TERMINAL PERFORMANCE OBJECTIVE

Using the appropriate tools and testing equipment, test and analyze a spark ignition engine converted to ethanol. Mastery of this task will be shown by obtaining 9 out of 9 points or 100% on a product checklist.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Test and analyze a spark ignition engine for power output.
2. Test and analyze a spark ignition engine for exhaust emissions.
3. Test and analyze a spark ignition engine for road efficiency.
4. Test and analyze a spark ignition engine converted to ethanol.

MICRO-PERFORMANCE OBJECTIVE #1

Test and analyze a spark ignition engine for power output.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how a spark ignition engine is tested and analyzed for power output.	1. Instructor Demonstration performed in Lab.
2. Follow the instructions in Resource 2 to practice testing and analyzing a spark ignition engine for power output.	2. Operator's Manual for the dynamometer you are using. Obtain the Operator's Manual from your Instructor.
3. Go to Resource 3 after Instructor approves your operation of the dynamometer.	3. Micro-Performance Objective #2 in this Learning Guide.

MICRO-PERFORMANCE OBJECTIVE #2

Test and analyze a spark ignition engine for exhaust emissions.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how a spark ignition engine is tested and analyzed for exhaust emissions.	1. Instructor Demonstration performed in Lab.
2. Follow the instructions in Resource 2 to practice testing and analyzing a spark ignition engine for exhaust emissions.	2. Operator's Manual for the exhaust performance analyzer you are using. Obtain the Operator's Manual from your Instructor.
3. Go to Resource 3 after Instructor approves your operation of the exhaust performance analyzer.	3. Micro-Performance Objective #3 in this Learning Guide.

MICRO-PERFORMANCE OBJECTIVE #3

Test and analyze a spark ignition engine for road efficiency.

LEARNING STEPS	RESOURCES
1. View Resource 1 to observe how a spark ignition engine is tested and analyzed for road efficiency.	1. Instructor Demonstration performed in an ethanol-powered vehicle under road conditions.
2. Complete Resource 2 to practice testing and analyzing a spark ignition engine for road efficiency.	2. Activity Sheet 800-003-001: "Testing and Analyzing a Spark Ignition Engine for Road Efficiency" in this Learning Guide.
3. Go to Resource 3 after Instructor approves Activity Sheet.	3. Micro-Performance Objective #4 in this Learning Guide.

ACTIVITY SHEET

800-003-001

Testing and Analyzing a Spark Ignition Engine
for Road Efficiency

Instructions: Complete the following operations.

1. Ask the instructor for a car or truck with a spark ignition engine that has been converted to ethanol.

2. Compute the vehicle's fuel consumption rate under road conditions (miles per gallon):

3. Give a brief analysis of the vehicle's acceleration performance:

4. Give a brief analysis of the vehicle's idle performance:

5. Give a brief analysis of the vehicle's starting performance:

MICRO-PERFORMANCE OBJECTIVE #4

Test and analyze a spark ignition engine converted to ethanol.

LEARNING STEPS	RESOURCES
1. Review Resource 1 on how to test and analyze a spark ignition engine converted to ethanol.	1. All Micro-Performance Objectives and Resources used in this Learning Guide.
2. When you are ready to perform this task without assistance, ask your Instructor to administer Resource 2.	2. Product Checklist Task 800 in this Learning Guide.
3. See Resource 3 to begin next Learning Guide.	3. Instructor.

PRODUCT CHECKLIST

Task 800

		YES	NO
1.	Was the instructor asked to provide a vehicle that had been converted to ethanol?	( )	( )
2.	Was the engine's horsepower tested and analyzed properly?	( )	( )
3.	Was the engine's exhaust smoke tested and analyzed properly?	( )	( )
4.	Was the engine's oil pressure tested and analyzed properly?	( )	( )
5.	Was the engine's alternator or generator tested and analyzed properly?	( )	( )
6.	Was the vehicle's fuel consumption rate computed correctly?	( )	( )
7.	Was a correct analysis of the vehicle's acceleration performance given?	( )	( )
8.	Was a correct analysis of the vehicle's idle performance given?	( )	( )
9.	Was a correct analysis of the vehicle's starting performance given?	( )	( )

Total Points	(9)			
Points Earned	( )			
Number Needed for Mastery	(9)			
Performance Attempt	1	2	3	4
Date of Attempt	____	____	____	____

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A LEARNING GUIDE

900

TASK Identify major techniques and developments of ethanol engine conversion as stated in current magazine and journal articles.

PURPOSE To stay informed of the research going on in ethanol engine conversion, the ethanol conversion technician reads magazine and journal articles dealing with conversion techniques and developments. These publications offer new ideas and experimentation that often lead to better ways of converting engines. The successful conversion technician knows the importance of keeping informed through reading.

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TERMINAL PERFORMANCE OBJECTIVE

Given a written criterion exam, identify major techniques and developments of ethanol engine conversion as stated in current magazine and journal articles. Mastery of this task will be shown by scoring 24 out of 30 or 80% on the exam.

MICRO-PERFORMANCE OBJECTIVE(S)

1. Identify major techniques and developments of ethanol engine conversion as stated in current magazine and journal articles.

MICRO-PERFORMANCE OBJECTIVE #1

Identify major techniques and developments of ethanol engine conversion as stated in current magazine and journal articles.

LEARNING STEPS	RESOURCES
1. Read five selections of your choice from Resource 1 to identify major techniques and developments of ethanol engine conversion.	1. Information Sheet 900-001-001: "A Bibliography of Current Articles on Techniques and Developments of Ethanol Engine Conversion" in this Learning Guide.
2. Complete Resource 2 to practice identifying the major techniques and developments of ethanol engine conversion as stated in your five selections.	2. Activity Sheet 900-001-002: "Identifying Major Techniques and Developments of Ethanol Engine Conversion" in this Learning Guide.
3. After the Instructor approves the Activity Sheet and when you are ready to be evaluated on this objective, complete Resource 3.	3. Written Criterion Exam Task 900 from Instructor.
4. See Resource 4 to begin next Learning Guide.	4. Instructor.

INFORMATION SHEET

900-001-001

A Bibliography of Current Articles on Techniques and Developments of Ethanol Engine Conversion

"Bioenergy: Fuel that Grows on Trees." Science News 118:70 August 2, 1980.

"Brazil's Alcohol Diesels." Mother Earth News 64:86 July/August 1980.

"Brazil's Alcohol-Powered Cars." Mother Earth News 66:160 November/December 1980.

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"Cornfed Cruiser." Mother Earth News 67:186 January/February 1981.

"Dual-Fuel Car." Mechanics Illustrated 76:151 April 1980.

"Exxon? Putting Ethanol in Gas Tanks." Forbes 116:23 September 15, 1975.

Flynn, D.L. "Alcohol Questions and Answers!" Mother Earth News 65:116 September 10, 1980.

Grammer, M. "Brazilian Alcohol: In the Tank, Not on the Table." Technology Review 82:10-12 May 1980.

Ludvigsen, K. "Alcohol Comes Back to Power Your Car." Mechanics Illustrated 74:46+ January 1978.

"Mother's Dual-Fuel Alcohol-Powered Van!" Mother Earth News 67:108-9 January/February 1981.

"Mother's Experimental Alcohol-Powered Truck." Mother Earth News 59:78-80+ September 1979.

"Mother's Alcohol Fuel Preheater." Mother Earth News 61:86-7 January 1980.

"Mother's Alcohol Road Show." Mother Earth News 63:38 May/June 1980.

Nerpel, C. "Booze Burners." Motor Trend 32:100 March 1980.

"Proof It Works: Use of Alcohol-Powered Vehicles in Brazil." Time 116:62 December 22, 1980.

Sherman, D. "Bullish Over Biofuel Futures." Car and Driver 26:19 August 1980.

Sklar, S. "Alcohol-Powered Car?" Blair and Katchums 7:70-2 January 1980.

"We've Been Asked About Using Alcohol as a Fuel for Automobiles." U.S. News and World Report 84:51 January 16, 1978.

"Whatever Happened to Alcohol as Fuel: Grain to Fuel Cars?" U.S. News and World Report 80:86 April 12, 1976.

Wilson, R.C. "A Little Alcohol Couldn't Hurt." Car and Driver 26:58 August 1980.

ACTIVITY SHEET

900-001-002

Identifying Major Techniques and Developments of Ethanol Engine Conversion

Using what you have learned from the five selections you chose from "A Bibliography of Current Articles on Techniques and Developments of Ethanol Engine Conversion," identify major techniques and developments of ethanol engine conversion. Once you have finished, submit this activity sheet to your instructor for approval.

Choice 1:

Choice 2:

Choice 3:

Choice 4:

Choice 5:

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BIBLIOGRAPHY

Following is a comprehensive list of resources used in this competency based curriculum guide. The important thing to remember is that this list represents the reading materials deemed important by the instructors of Southeastern Illinois College's ethanol engine conversion curriculum. For others, it merely represents recommended reading assignments. Keep in mind that the curriculum guide is designed to allow instructors the flexibility of selecting their own bibliographical sources.

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Bidwell, Joseph. "Automobile Fuels--Outlook for the Future." Report No. GMR-2733. Warren, Michigan: General Motors Research Laboratories, 1978.

Blaser, Richard F., comp. *Alcohol Motor Fuels for Internal Combustion Engines: A Compilation of Background Technical Information*. Washington, D.C.: U.S. Department of Energy, 1980.

Bossong, Ken. "A History of Alcohol Fuels." *Alcohol Fuels: Opportunities for Idaho*. Washington, D.C.: U.S. Department of Energy, 1980.

Brown, Michael H. *Brown's Alcohol Motor Fuel Cookbook*. Cornville, Arizona: Desert Publications, 1979.

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Solar Energy Research Institute. "Fuel from Farms--A Guide to Small Scale Ethanol Production." Report No. SERI/SP-451-519. Washington, D.C.: U.S. Department of Energy Midwest Research Institute, 1980.

U.S. Congress. Senate. Committee on Appropriations. "Alcohol as an Alternative Fuel, Special Hearing on Alcohol Fuels." 95th Congress, 2nd session, 1978.

U.S. Congress. Senate. Committee on Appropriations. "Engine Conversion for Alcohol Fuels, Special Hearing on Alcohol Fuels." 95th Congress, 2nd session, 1978.

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